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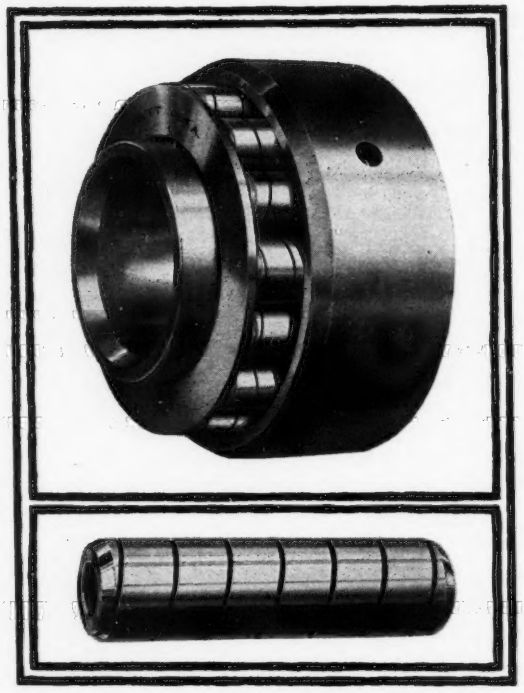

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The Journal of Engineering as Applied to Agriculture

Vol. 8 DECEMBER, 1927 No. 12

Artificial Drying of Alfalfa and Other Crops*

By H. E. Kiefer[1]

SPEAKING at the World Economics Conference at Geneva recently, Prof. E. M. East of Harvard University made some remarks to the effect that in 2027 A. D. the population of the world will be five billions, and since it takes two and one-half acres to support each person and the total acres that can be cultivated is but thirteen billions, the limit will be reached. This caused widespread comment in all civilized countries, much of it being pessimistic in tone, but it is only fair to note that the professor qualified his remarks by naming several possibilities that might forestall the predicted food shortage.

The work referred to is that of Arthur J. Mason of Chicago. After about thirty years of work in his chosen field of engineering, he felt the necessity of more recreation and purchased a farm at Homewood, twenty-five miles south of Chicago, as a site for a country home. His love of nature led him to become interested in agriculture, and being a scientific man he began with a study of the soils. Several years were devoted to this with a view of determining the loss of fertility due to erosion. By means of hundreds of test pits dug in pairs, one along the right-of-way of the Illinois Central Railroad, where virgin prairie conditions existed, and the other just inside the fences where the land had been tilled for possibly seventy-five years, he found in that comparatively flat country two inches more soil under the prairie sod than in the cultivated field a few feet away. Two inches out of a total of seventeen lost by erosion in less than a century is a serious thing.

It took nature millions of years to make that soil. Her method of preserving it was by keeping it covered with sod, thereby reducing erosion to a minimum. Man's method of destroying it is to keep it in cultivated crops, thus exposing it to the wash of surface waters and eventually depositing it in the sea. It became apparent that the first objective in preserving fertility for future generations is to keep as much of the land as possible in sod crops.

The next step was to ascertain if such a system was practical. Here again we must study the processes of nature. Seventy per cent of our farm acreage is given to raising feed for animals. In the processes of evolution animals adapted themselves to the plant food that was available, and this consisted largely of grasses as there was no one to supply cultivated crops. As a result an animal's digestive tract is naturally adapted to the plants which formed a sod covering.

Forage crops are, therefore, the animal's natural feed, but in order to produce a more rapid growth for purposes of meat and an excessive flow of milk, man provides concentrates. In general, these latter are the cultivated crops responsible for greater erosion.

Concentrates may be fed in limited amounts, but a digestive tract that took millions of years to adapt to coarse, bulky feeds high in fiber can not be altered in several thousand years to a ration of concentrates. Even if we could prove that it is advisable, we could not hope to eliminate roughages except by gradually increasing the amount of concentrates for many ages to come.

Roughages must continue a basal part of an animal's rations, and the second objective is to determine which of the hays is most economical. Granting that all sods protect the soil, the question is one of relative feeding value combined with yield per acre, the cost per unit, and the effect on fertility of the soil. The legume hays are the most important, and of these clover and alfalfa are grown most extensively.

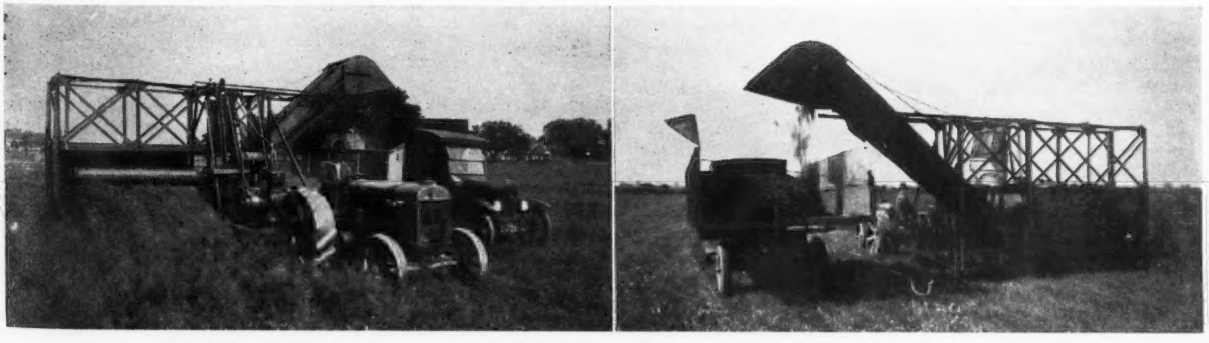
It is well, therefore, to make a comparison of sun-cured alfalfa with sun-cured clover hay, taking representative analyses in each case (see Table I).

TABLE I. Chemical Analyses of Sun-Cured Clover and Alfalfa

	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
Clover	12.3	8.3	12.8	25.7	38.4	2.5
Alfalfa	8.6	8.6	14.9	28.3	37.3	2.3

It will be noted that pound for pound alfalfa contains slightly more nutrients than clover. If only these two feeds were to be considered it might be preferable to compare the digestable nutrients, but such would be misleading as to what is to follow.

As there is such a wide difference in yields per acre of



Two views of the tractor-propelled mowing machine used in the Mason system of alfalfa production

*Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Pittsburgh, Pa., October, 1927.

[1]Vice-president, The Mason Alfalfa Process Company.

any crop, we feel that general principles are best represented by taking the average yields for the entire United States. For clover in 1925 this was 1.35 tons, and for alfalfa 2.6 tons.

TABLE II. Average Yield of Nutrients in Pounds Per Acre in the United States

	Protein	Fiber	Nitrogen-free extract	Fat	Total
Clover	346	693	1039	67	2145
Alfalfa	778	1577	1947	120	4222

It will be noted (Table II) that alfalfa is only slightly superior in chemical analysis, but it yields almost double the number of pounds of nutrients per acre. This being the case, the question arises, Why is it not grown more extensively? There are several reasons:

1. The long life of the stand does not fit in well with the the usual rotation of crops.
2. The second and third cuttings interfere with the labor program of other crops.
3. It is difficult to cure.

The first and second objections might be easily overcome, but it is well known that in the humid regions, where alfalfa thrives best, it is most difficult to cure. Many eastern farmers who succeeded well with alfalfa in small acreages became ambitious and put out larger acreages, only to find out that the difficulty of curing it in the sun made the saving of the entire crop impossible.

If a practical method could be devised for artificially curing alfalfa, the third objective would be attained. Arthur J. Mason reasoned that if a ton of brick, which sold for about $3, or salt requiring a great deal of water to be evaporated, could be artificially dried and sold for $3 a ton, hay worth about five times that amount would warrant the same artificial treatment. This view was further strengthened by the fact that all kinds of hays cured in the sun are subject to wide variations in feeding value depending upon the kind of weather encountered at haymaking time. A further objective would be to make hay, rain or shine, at the most desirable stage of growth, thereby obtaining a uniform hay of a superior feeding value. How well he succeeded is shown by the following comparison of sun-cured alfalfa and his artificially cured product.

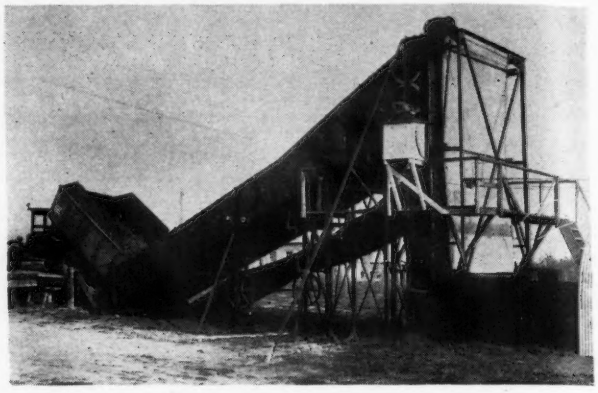
TABLE III. Chemical Analyses of Sun-Cured and Artificially Cured Alfalfa

	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
Sun-cured alfalfa	8.60	8.60	14.90	28.30	37.30	2.30
Artificially cured alfalfa	8.29	8.87	19.25	21.43	39.30	2.86

A glance at these figures (Table III) shows that the artificially-cured alfalfa contains one and three-tenths times as much protein and only about three-quarters as much fiber as the sun-cured alfalfa. The high protein and low fiber are due to two causes: Minimum losses of nitrogen by fermentation during curing, and no loss of dry leaves in the field as in sun-curing.

This latter developed the fifth objective, namely, a larger yield per acre. On this point we depend upon Prof. Headden in Colorado Experiment Station Bulletin 110, from which we quote: "The general custom in this part of Colorado is to rake the alfalfa into windrows as soon after cutting as is at all advisable, and complete the necessary curing in windrow or cock as the case may be. This practice is the result of the observed loss of leaves and breaking off of small stems in raking and handling, if allowed to overcure in the swath. The loss, that is, the leaves and stems which fall or are broken, amounts, under favorable circumstances, to about one-fifth of the crop, and can if it is necessary to repeatedly handle the hay, amount to as much as two-thirds of the crop, which of course remains on the ground to enrich it."

As the unavoidable loss in best weather is 20 per cent and losses in poor weather may be as high as 66 per cent, it is safe to assume the average loss in sun-curing alfalfa is not less than 30 per cent. Figuring on a loss of only 20 per cent. the average yield of 2.61 tons per acre for the United States shows that there actually was 3.25 tons grown and cured, and as the Mason system saves everything we may compare the number of pounds of nutrients per acre using this weight and the analysis given, which is a fair average of a number of samples, with a yield of 2.61 tons of sun-cured alfalfa.



This view shows a truck unloading alfalfa. The inclined conveyor delivers the alfalfa to the tower shown, where it is prepared for delivery to a horizontal conveyor running the entire length of the drier

TABLE IV. Total Nutrients in Pounds Per Acre of Sun-Cured Alfalfa and Masonized Alfalfa

	Total weight	Protein	Fiber	Nitrogen-free extract	Fat	Total nutrients
Sun-cured ...	5220	778	1577	1947	120	4222
Masonized ...	6500	1251	1392	2554	186	5383

It is apparent from the chemical analysis (Table IV) that artificially cured alfalfa should give better results pound for pound than the sun-cured. Actual feeding tests at the Walker-Gordon milk farms, where one of the Mason plants has been in operation all this season, showed that, when they changed from feeding the best western alfalfa to this product and feeding the same weights, there was a decided increase in the milk output. A preliminary report on the vitamin contents as shown in comparative tests on white rats at Columbia University shows the superiority of the artificially cured alfalfa meal as does also a preliminary report on young pigs at the New Jersey Experiment Station.

Sun-cured alfalfa is now used to a certain extent to replace concentrates. A number of experiment stations agree that it is about equal to wheat bran in feeding value. The higher protein content and lower fiber of the artificially cured must necessarily permit it to be used to a greater extent in replacing concentrates and give it a higher feeding value than wheat bran.

Artificial curing of alfalfa is an accomplished fact. Its superior feeding value has been demonstrated. The recovery of a greater tonnage per acre is verified, and the only question is whether its cost is prohibitive.

The question of cost is of greatest importance, but those of us who have been engaged in both manufacturing and agriculture can appreciate how much more difficult it is to determine the cost of a unit of farm product than the unit of product in a factory. In the latter case we are producing one or more articles all the year round. Interest on investment, taxes, insurance, overhead of all kinds, and other incidentals are added to our actual factory costs and an approximate cost per unit is obtained.

On a farm it is widely different. We can figure land rental, taxes, insurance and overhead on an acreage basis. We can figure our crop costs, including man labor, horse labor, tractor expense, seed, fertilizer, machinery expense, etc., for each crop individually, but practically all of these costs come in a period from April to October, and then we take no account of the rainy days or days we can not get on the fields. Where do we charge these, or many days in the winter? To what crops are we to charge our teams when they are in the barns, which is a considerable portion of the time? We know how many man, horse, tractor, and machinery-hours it takes to make a ton of hay. We know land rental, seed fertilizer costs, etc., but I say advisedly we do not know the actual cost of a ton of hay and never

will until we put it on a factory basis and prorate our total annual expenses over our total crop yields.

One of the resolutions of the Thirteenth International Agricultural Congress at Rome, 1927, read as follows:

"The scientific organization or rationalization of agricultural labor and production has become an essential necessity for agriculture. The special study of the labor factor in production processes and of the relation between work done and effective output will make it possible to obtain the optimum result with the minimum expenditure of effort, at the same time raising the standard of health and welfare for all who are concerned in agricultural production."

The Mason Process. The Mason system is a plan to put the production of alfalfa hay or meal and also, as will be seen later, other hay crops on a factory basis. That is, to keep one gang of men working continuously rain or shine every working day during the haymaking season, and then either to dispense with their services or provide other regular employment for them the balance of the year.

To get the maximum efficiency the unit is based on a fair capacity for a 7-ft. mowing machine in 10 hr. This was found to be about 15 acres. The mowing machine used, however, is radically different from those in general use. It automatically picks up the alfalfa as cut, passes it to a recutting device for reducing lengths to 12 in. or less, and transfers it to a truck traveling at its side. There is no raking as none of it ever touches the ground. There is only one pitchfork on the job for 20 tons of hay daily, and it is used only at rare intervals. Within a few minutes after the alfalfa is cut it is in the dryer and within an hour it is cured, ground to meal, and stored away.

One man is required on the tractor drawing the mower and loader. One driver is needed for each of the trucks, there being three or four required, depending on the length of haul. One man is stationed at the receiving end of the dryer, one at the discharge end, and one for firing the furnaces.

Power required is one 10-hp. gasoline engine mounted on the mower, a 15-hp. tractor, and three or four trucks. At the plant one 10-hp. motor at the receiving and one 10-hp. motor at the discharge end, one 40-hp. motor on the grinding mill, and a 50-hp. motor to drive the fan supplying the heated air.

The drier may be described as follows: The truck dumps its load to an inclined canvas conveyor 9 ft. wide which delivers it to a tower at the head of which are three carding or combing rolls. These tear the matted alfalfa to practically individual strands and drop them to a vertical moulding or mattress-forming chamber where gravity arranges them into a ribbon 8 to 12 in. thick as desired and 9 ft. wide. One side of this chamber is formed of a traveling metal curtain which draws the mattress in a continuous stream to a horizontal traveling conveyor of wire mesh. This moves slowly through a double-walled tunnel 150 ft. long. Heated air and gases from a furnace enter at the discharge end and in that half of the tunnel filter slowly downward through the felted mattress. They pass under a baffle and upward through the mattress on the receiving end and escape to the open air.

At the discharge end a combing roll tears the mattress apart and delivers the perfectly cured and bright green hay to a conveyor which in turn delivers it to the grinding mill, the fan of which blows the finished meal into the storehouse. The gases enter the dryer at 275 deg. F., and we find at this temperature it completely sterilizes the weed seeds. A feed that does not promote weeds via the manure route is another virtue claimed for this process.

Reference has been made before as to costs. In general the operating cost from the standing alfalfa to the meal in the storehouse will run from $7 to $10 per ton. If we deduct from this the cost of harvesting, curing, and storing in the usual way we have an amount which is more than offset by the increased tonnage per acre and superior feeding value.

The Mason system is not adapted to small farms as it requires alfalfa to the extent of 400 to 600 acres to keep it operating steadily from the date of the earliest to the latest cutting. While the greatest number of pounds of nutrients per acre of single crop can be obtained from alfalfa, other crops such as soybeans, cowpeas, wheat hay, rye hay, oat hay, etc., may be readily cured. Some of these hold very great promise for the future as by means of frequent planting more than one crop per year may be obtained.

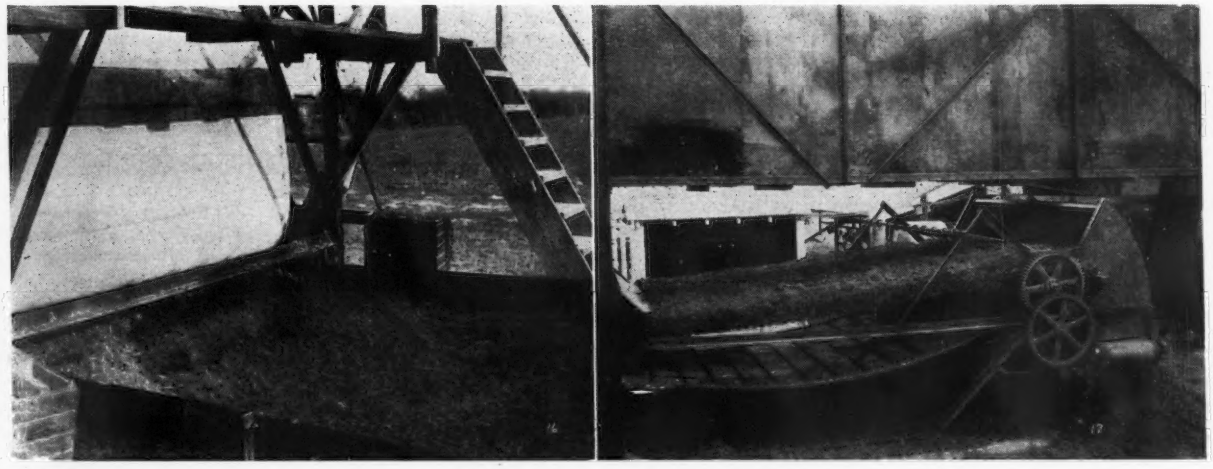
Dr. E. B. Voorhees, director of the New Jersey Agricultural Experiment Station, spent a number of years experimenting on soiling crops with a view of introducing the European system into this country. High cost of labor and other conditions make it impractical in this country, but his book on forage crops contains startling facts as to the number of pounds of nutrients that can be raised per acre. Voorhees actually produced them but was compelled to feed them green. It never occurred to anyone to desiccate them or if it did there was no suitable apparatus.

Possibilities of Rye. Voorhees used rye cut in the milk stage as one of his soiling crops. We quote from him: "The yield per acre, even under good methods of management, will vary widely, according to character of soil and season. The range is from 4 to 12 tons per acre. In experiments at the New Jersey station, the average yield for 7 years has been 7 tons per acre."

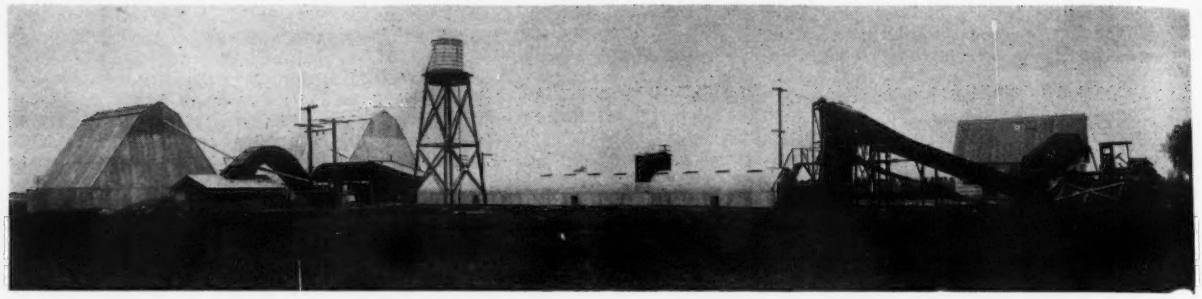
From a chemical analysis of the green rye he calculated the pounds of nutrients an average acre yields:

Dry matter	2,527.0 lb.
Protein	298.2 lb.
Crude fiber	600.6 lb.
Nitrogen-free extract	1,345.4 lb.
Fat	91.0 lb.
Ash	259.4 lb.

His maximum yield of 12 tons of green crop would have yielded 4,332 lb. of dry matter, or allowing 10 per cent mois-



(Left) Alfalfa leaving the tower to enter the drier. Note the uniform distribution of alfalfa on the conveyor. (Right) This shows the alfalfa leaving the drier for delivery to the grinding mill



Complete view of plant used in the Mason system of alfalfa production—sheet steel storages and bagging shed, drier, tower, elevator and truck unloading

ture in the desiccated hay about 4,800 lb. Calculated to this moisture basis the analysis becomes:

10.0 Moisture
6.7 Ash
10.6 Protein
21.5 Fiber
48.0 Nitrogen-free extract
3.2 Fat

Mr. Mason and the author have been conducting tests on young crops cut even more prematurely than the milk stage. In fact, these have been cut before heading or blooming. On the farm at Burlington, New Jersey, rye was cut on April 21 when about 18 in. high and quickly cured in an oven. The yield of hay was at the rate of 2 tons per acre. Two samples were taken from different parts of the field and the hays therefrom sent to two agricultural experiment stations, which reported as in Table V.

TABLE V. Results from New Jersey and Delaware Stations

	New Jersey Experiment Station	Delaware Experiment Station
Water	9.99 per cent	7.96 per cent
Ash	10.27 per cent	8.51 per cent
Protein	22.56 per cent	22.60 per cent
Fiber	15.27 per cent	16.28 per cent
Nitrogen-free extract	36.30 per cent	38.34 per cent
Fat	5.61 per cent	6.31 per cent

In Table VI will be found analyses of sun-cured rye hays, the calculated Voorhees hay and the artificially cured hays.

TABLE VI. Chemical Analyses of Different Hays

	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
From Henry and Morrison: Rye hay—all analyses	8.1	5.1	6.7	37.5	40.5	2.1
Rye hay—heading out to bloom	8.2	5.8	9.8	33.9	39.7	2.6
Calculated Voorhees rye hay	10.0	6.7	10.6	21.5	48.0	3.2
Early cutting rye artificially cured:						
N. J. Experiment Sta.	9.99	10.27	22.56	15.27	36.30	5.61
Del. Experiment Sta.	7.96	8.51	22.60	16.28	38.34	6.31
Analyses of rye as grain	9.4	2.00	11.8	1.80	73.2	1.80

In Table VI the analysis of rye as grain is given, and assuming sixteen bushels as an average crop it is possible to compare the yield of nutrients per acre with those of the several rye hays.

TABLE VII. Nutrients in Pounds Per Acre

	Protein	Fiber	Nitrogen-free extract	Fat	Total nutrients
Voorhees average	298.2	600.6	1345.4	91	2335
Burlington rye before heading	902.0	610.0	1452.0	224	3188
Sixteen bushels rye as grain	113.0	17.0	703.0	17	850

It will be noted (Table VII) that about eight times as much protein can be obtained from artificially cured rye hay as from the grain itself. Why give a year's use of the land to getting a total of 850 lb. of nutrients when 3,188 lb. can be taken off in the spring in time to plant another crop—oats or corn for instance?

Artificially Cured Oat Hay. Voorhees used oats also as a soiling crop and reports 4 to 10 tons green feed per acre. He gives figures as in Table VIII.

TABLE VIII. Voorhees Figures for Artificially Cured Oat Hay

	Green forage	Hay	An average acre yield furnishes —pounds
Water	75.00 per cent	25.00 per cent	
Dry matter	25.00 per cent	75.00 per cent	3500
Ether extract (fat)	.92 per cent	2.76 per cent	128
Fiber	7.40 per cent	22.20 per cent	1036
Protein	2.25 per cent	6.75 per cent	315
Ash	1.65 per cent	4.95 per cent	231
Nitrogen-free extract	12.77 per cent	38.31 per cent	1787

At his Burlington farm the author planted oats on July 17 and cut and cured the hay artificially on August 17, getting a yield of ¾ ton per acre. In the chemical analysis made by the New Jersey Experiment Station it will be noted that the ash is abnormally high. This is explained by the fact that several days before it was cut a heavy storm beat it to the ground and the rain splashed silt over it. As this is a condition that may be met in large operations no effort was made to remove it other than shaking.

TABLE IX. Analyses of Various Oat Hays and Oats as Grain

	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
Henry and Morrison oat hay	12.00	6.8	8.4	28.3	41.7	2.8
Voorhees' oat hay	25.00	4.95	6.76	22.20	38.31	2.76
Burlington experiment	13.08	20.85	23.43	19.07	19.27	4.30
Oats (as grain)	9.20	3.5	12.4	10.9	59.6	4.4

Taking 35 bu. as an average yield of grain per acre, the figures of Voorhees and the Burlington experiment data, Table X is constructed.

TABLE X. Yield of Nutrients per Acre in Pounds

	Protein	Fiber	Nitrogen-free extract	Fat	Total nutrients
Vorhees' oat hay	315	1036	1787	128	3266
Burlington experiment (one month growth)	351	286	289	64	990
Oats as grain	269	122	667	49	1107

Artificially Cured Wheat Hay. In some sections it is a practice to pasture sheep on the wheat during the winter, apparently without affecting the yield of grain at harvest. Acting on this principle, Mason cut the same piece of wheat on April 3 and April 27 in Tennessee and cured it artificially, getting at the rate of 5,500 lb. of dry hay per acre. Analysis of this was made by the state chemist of Tennessee (see Table XI).

Taking 18 bu. as an average wheat yield and one ton as a hay yield by artificial curing, we estimate for comparison the nutrients per acre (see Table XII).

TABLE XI. Analyses of Milk-Stage Wheat Hay, Wheat as Grain and Artificially Cured Wheat Hay

	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
Milk-stage wheat hay..	8.10	6.40	6.20	24.70	52.60	2.00
Voorhees' calculated wheat hay	10.00	7.10	9.50	23.30	47.20	2.80
Artificially cured wheat hay	8.54	12.36	18.25	19.71	36.58	4.56
Wheat as grain	10.20	1.90	12.40	2.20	71.20	2.10

Experiments are under way to demonstrate this principle on a large scale on all the small cereals. In any event, the tradition of centuries that in grain farming a year is the cycle of a crop should be revised, as saving the land's time is as important as saving man's time.

Our results show that more nutrients per acre can be obtained in four to ten weeks than by permitting these crops to mature as grain, and, furthermore, the land can be cropped twice instead of once a year. A study of the possibility of triple cropping is under way.

A study of the chemical processes of the growing plant is also under way, but at this time is at a stage requiring confirmation. In the foregoing analyses nitrogen is calculated as protein by the state chemists. As a matter of fact we know that in immature plants it exists in the amid state or as amino acids. Proteins existing in the mature plants are complex compounds built up of these more elementary constituents.

Compared with proteins, amids are relatively unstable and we believe have a higher feeding value. Authority is not lacking in support of the statement that in the processes of digestion proteins must be broken up into their constituent amids before being assimilated. This involves an expenditure of a certain amount of animal energy that might be saved if we can preserve the amids for future use.

Authorities differ as to their feeding value, but we are of the opinion that it is greater than that of proteins and cite the great increase in flow of milk when cattle are put on spring pasture where from our present knowledge cattle get amids rather than protein as in matured feeds. We know that silage promotes the flow of milk, and also during fermentation its protein is partly broken up into its simpler constitutents. These and other instances that might be cited lead to the belief that we prepare our feeds with the nitrogenous matter as protein, because it is the easiest way. Nature takes care of the preservation with some assistance from man.

A study of the foregoing figures leads to the theory that there are three prominent stages in the growth of a plant. The first stage is the early growth, during which the formation of amino acids, fats and nitrogen-free extract is the principal action. The second stage is additional growth of the plant to prepare for blooming and during this stage the plant must be given a greater rigidity to withstand the winds and support the grain. Fiber as cellulose is required for this, and in Table VI we see a progressive increase of fiber from the early-cut, artificially cured rye to the milk-stage hay. We also find a corresponding decrease in the nitrogen calculated as protein.

It is worthy of note here that long before chemical analyses or vitamins were known man learned to eat his leafy vegetables in the young and tender state when the fiber content is low and the nitrogen compounds high. They are more palatable, more digestible, have a higher food value and undoubtedly more vitamins. He is content to give his farm animals such feeds only when he can send them out to forage for themselves. That an animal instinctively uses the same judgment as man is shown by the fact that it always selects the most tender plants.

The third stage is when the more soluble elementary nitrogen compounds are transported from the plant to the seed and converted into protein.

If this view is correct, then it would seem wasteful to utilize the land's time for an entire season when more and better feed can be obtained in a much shorter time. Vim, vigor, vitality and vitamins are characteristics of youth, not old age.

TABLE XII. Wheat: Total Nutrients in Pounds per Acre

	Protein	Fiber	Nitrogen-free extract	Fat	Total nutrients
Voorhees' wheat hay, 4035 lb. per acre.....	384	944	1904	112	3344
Artificially cured wheat hay, 5500 lb. per acre	1004	1084	2012	251	4351
Eighteen bushels grain.	134	24	769	23	950

In many cases the maturing stage is one of loss, not gain. Reference to the tables, that of rye particularly (see Table VII), will show that the combined weight of the protein in the grain with that in a liberally assumed weight of straw to accompany it is far short of that obtained on April 21 by artificially curing it when 18 in. high and some time before blooming. The same applies to the yield of fat per acre. The table on wheat shows even more remarkable results. If the experiments now under way on a large scale confirm this, then the second and third stages are ones of losing nutrients, losing land's time, man's time, and stamp our centuries-old practice of feeding animals as one based on a misconception of the facts.

Mason's work on artificially curing alfalfa has demonstrated that it is possible to increase the tonnage of food in the United States by millions of tons and thus set Professor East's shortage much farther in the future. If to alfalfa we add cereals and possibly other crops we may rest assured that it will only be in that very, very distant future that synthetic foods will be necessary unless the chemist can prove in the meantime that synthetic foods are superior or possibly the elixer of life.

SUMMARY

1. Keeping the soil covered with sod reduces the loss of fertility due to erosion to a minimum. Frequent cultivations or exposure during the winter increases this loss. Nature protects; man destroys.
2. Nature adapted the digestive tract of ruminants to bulky feeds high in fiber. Our hays fall in this class.
3. Concentrates encourage growth and increase flow of milk. Reducing the fiber in roughages brings them nearer the concentrate class.
4. Artificial curing of some young crops makes feeds superior to some concentrates.
5. Alfalfa protects the soil, enriches it and yields a greater number of pounds of nutrients per acre than any other crop.
6. Artificial curing of alfalfa not only results in a much superior feeding value, but by avoiding field losses enables the recovery of at least 20 per cent greater tonnage per acre.
7. Artificial curing eliminates the weather hazard to a large degree.
8. Steady work of one kind during the entire season promotes labor efficiency.
9. Artificial curing sterilizes all the weed seeds.
10. Artificial curing of other crops is both practical and desirable.
11. Sun-cured rye hays as known at present contain less protein than the grain. Artificially cured rye hay contains almost double the amount of protein and treble the amount of fat.
12. Almost four times as many pounds of nutrients per acre has been obtained by artificially curing rye hay as from an average acre of the grain. Eight times as much protein has been obtained. Similar results were obtained on wheat.
13. These results were obtained in the spring early enough to permit the use of this land for another crop.
14. Good results were obtained from oat hay, indicating a possibility of getting large crop yields in less than eight weeks.
15. The studies have shown that the tradition of a year as the cycle of a crop must be abandoned and double or triple-cropping substituted.
16. Both man's time and the land's time must be conserved. Farm practices should be on a scale large enough to put the labor organization on a factory basis.

Silt Control for Drainage and Flood Ditches*

By R. N. Towl†

EGYPT, China and India furnish many fine examples of the problem of making and maintaining suitable drainage and flood channels. The primary cause of floods in alluvial valleys is channel deterioration caused by sedimentation. In ordinary years of low flow the tributaries and head waters bring in a greater burden of sediment than the ditch or stream can transport. Silting shrinks the channel and floods result for lack of capacity.

Often it is desirable to have occasional floods to flush out certain channels and check the growth of weeds and other vegetation, which retard free flow and transportation of debris. A sustained or constant flow is also beneficial in a silting stream. Channel condition has a direct influence on discharge capacity.

The question is often asked, "What are the factors in silt transportation in running water?" Without technical formulation these factors will be presented for consideration as follows:

1. Head, or fall, produces velocity and supplies all of the energy used by the stream under the law of gravity.
2. Friction retards velocity and consumes energy.
3. Velocity may be measured by the power or energy remaining after deducting all resistances to flow.
4. When friction or any resistance to flow is reduced, velocity will be increased.
5. Transportation of silt and debris, by rolling or bed movements and by suspension, takes energy from the stream and reduces velocity.
6. When velocity is reduced, in a stabilized channel, depth is increased.
7. When velocity is increased, in an unstable channel, depth is increased by scour and other resistance to flow, which consumes the excess energy or acceleration of velocity.
8. Increased depth requires increased energy to keep silt or sediment in suspension.
9. In the case of caving banks and scour in the outside of a bend, velocity is reduced and pressure increased. Here, evidently, energy is taken from velocity and consumed in erosion.
10. Finally, when a balance is reached between all of the factors, the most efficient cross-section and slope for a fully loaded stream may be expected.

The foregoing general suggestions are important but by no means all-inclusive. Chemical action, frost and the elements, wind, etc., play an important part.

Hence, it is always desirable to observe closely and be governed by natural operation of silt transporting streams. For example, the Colorado River in lower California has made a delta extending across the ancient Gulf of California with the Imperial Valley lying to the north. Obviously, when water stood over the Imperial Valley at sea level, silt from the Colorado River could not reach the north end of the Valley and fill it to the same extent as at the south and where the silt-laden stream entered.

Lack of application of such observations have resulted in levee failures and great losses of life and property. In 1887 the Yellow River of China flooded its valley at a cost of 900,000 lives.

In recent years levees have been built on the Colorado River to reduce flooding on the delta. This has resulted in raising the bed and banks of the stream, breaking of levees and diversion of the channel. The old bed has silted and there now remains no main channel to conduct the river across the delta to the Gulf, a distance of 30 mi. The rate of rise was about 1 ft. a year for 13 yr.

The Mississippi levee system, not completed to standard grade, has frequently failed to carry the great floods, in which cases the flood waters follow the bayous or natural clear-water outlets. Hence, there is a demand for a system of by-passes.

It is important in a great flood system to consider levees, spillways, reservoirs, retarding basins, check dams and various devices for bank protection and to restrict sedimentation at its source. It is also important in the smaller drainage systems, which may deteriorate gradually, to adopt the proper system of maintenance.

When rapid filling prevails, clean-out or reconstruction is not generally feasible. Relief may be had by diverting the silt-laden waters and separating them from the drainage system. If a satisfactory stream outlet is not available, or too costly, low lands may be used as settling or overflow basins, and the clarified water is returned to the drainage system. Or it may be possible to permit the offending stream to overflow near its entrance into the valley and build up a higher flood plain. In this case clear-water ditches should be provided to drain the flooded land as quickly as possible.

When such flooding is practiced, crops may be grown successfully if the waters are spread evenly over the gently sloping flood plain, as in irrigation. Also the frequent inundations will build up and enrich these lands.

Many details of interest will develop in any system. (For example, see the author's paper, entitled "Flood Regulation and Silt Control on the the Silver Creek Floodway," page 304, November, 1927, issue of AGRICULTURAL ENGINEERING, Vol. 8, No. 11.) Where a diversion ditch crosses a drainage system it is necessary to preserve the drainage through culverts under the floodway. These culverts should have seepage collars and corrugated sides to prevent seepage along the barrels and failure of embankments. Spillways or the margins of overflow ditches may be of earthen construction where an even depth of shallow water escapes. Naturally the banks are raised to an elevation near prevailing high-water marks and adjust the overflow to a fairly uniform depth and quantity. This is most desirable and may be assisted by a growth of willows or other vegetation. Sod is a sufficient protection for ordinary spillways if the slopes are fairly flat. Here again observations and experiments will dictate the cheapest and best details of construction.

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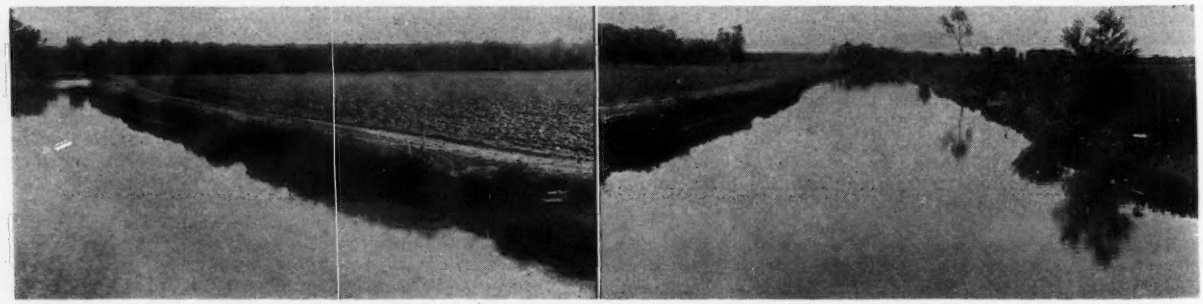

Two views of the Goldren River in Iowa, a natural flood plain

Possibilities in Tractor Research*

By J. B. Davidson[1]

ACCORDING to a survey of farm power made by C. D. Kinsman, and reported in Department Bulletin 1348 of the U. S. Department of Agriculture, the gas tractor furnishes 10 per cent of the total power used on the farm and 8 per cent of the draft work which makes up 70 per cent of the total. From the situation described it would appear that although in competition with other sources of power for the farm, the gas tractor, to say the least, has not secured the lead.

Research has for its ultimate goal increased economy. This may be secured in many ways, of which may be mentioned rearrangement and lowering of cost items, increasing the efficiency of performance, or improving the quality of output. All of these developments may in a measure be looked upon as methods of securing better economy. Analyses of tractor performance from these three standpoints may indicate in a general way the direction that research connected with the gas tractor should take. An assumed but rather typical analysis of tractor power costs is given in Table I.

From this it will be observed that the cost may vary as much as 200 per cent and yet be within the practical range of present day operation. The average annual tractor service as revealed by Mr. Kinsman's report is but 265 hr.

To the above must be added operating labor. If this is charged at 60 cents per hour then the charge per drawbar horsepower hour for 10 dhp. is 6 cents; 15 dhp., 4 cents, and 20 dhp., 3 cents.

When combined with tractor costs, the extremes in the cost of power and operator may vary from 26 cents per horsepower-hour to ten cents per horsepower-hour, almost a three-to-one difference.

TABLE I. Cost of a Horsepower-Hour from a Gas Tractor Costing $75.00 per Drawbar Horsepower

	Fixed charges annual	Hours of use annually 100	500	1000
Interest on $40, at 8%	$ 3.20			
Depreciation on $75, at 12½%	9.38			
Housing, taxes, and insurance	1.00			
Total fixed charges	$13.58	$.136	$.027	$.014
Fuel, oil, and care		.03	.03	.03
Maintenance		.03	.03	.03
Total per hour		$.196	$.087	$.074

With such a wide range of costs, it is obvious that there is a splendid opportunity for advancement in the matter of utilization. It is the author's judgment that, when tractor history is written, the matter of utilization will be cited as one of the outstanding obstacles to the development of the tractor. If the gas tractor is able to compete with other sources of power at an average cost of 20 cents per drawbar horsepower-hour, will someone venture an opinion as what to expect when developments are achieved which will enable the cost to be cut in half. Although tractor design has now reached the place where the tractor will complete the cycle of crop production and not necessitate a duplicate power plant to do a part of the work, the time has not yet passed when a careful analysis of the application and utilization of the gas tractor in crop production could not well be made, as many problems would be clearly presented which are obstacles to the more general use of the tractor.

A study of the cost of energy for farm power plants may be of interest. Although the low thermal efficiency of the motor using fuel furnishing energy at the lowest cost may make it the most expensive source of power, it is well to have in mind the relative cost of energy from various fuels.

TABLE II. Cost of Energy

Fuel	Cost, cents per lb.	Lower heat value, B.t.u.	B.t.u. for 1 cent
Corn-hay	1.00	6800	6800
Coal	0.50	12500	25000
Kerosene	1.75	18500	10570
Gasoline	3.50	18400	5285
Alcohol	7.00	11670	1667
Furfural	14.00	12000	857

An inspection of Table II would indicate that coal has a decided advantage in low energy cost. If the energy of coal could be utilized for gas tractors, there would be a decided advantage over all other motors. The situation revealed in this comparison of energy costs may be an explanation of the interest displayed in Europe in gas producer plants for trucks and tractors. Although fuel at the present time makes up only from one-third to one-tenth of the cost of tractor power and operation, the fuel problem is worthy of consideration. Liquid fuels from coal and shale should be studied, and the production of alcohols and furfural from vegetable sources should also be studied. Many who have studied the production of furfural believe that it ultimately may be produced at a figure which will bring it into competition with the fuels now in use.

*Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1926.

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Before the gas tractor can come fully into its own the very foundations of crop-production methods must be changed

As to the matter of thermal efficiency, the animal motor and the internal-combustion motor as used in the gas tractor are practically on an equal basis. The fact that the animal delivers power directly as draft, while the rotary motion of the gas motor is converted into linear motion, partly compensates for the fact that the animal consumes some fuel while idle.

The thermal efficiency of the internal-combustion motor used in the gas tractor is low when compared with that of best stationary practice under best conditions; it is much better than that of the motors used in pleasure cars. Constant compression-pressure motors would raise efficiency for normal operating loads, but it seems to be recognized practice to sacrifice efficiency for other advantages. It is not necessary to accept this view as final.

The next analysis which might be made in the search for research problems may be in connection with the efficiency of the application of the power of the gas motor. An analysis of the dispersion of the power of the motor of a gas tractor of the wheel type may average about as follows for favorable conditions, such as stubble ground when the tractor is used for plowing:

Power of motor	100 per cent	
Loss in transmission		15 per cent
Rolling resistance of tractor		25 per cent
Slippage		5 per cent
Delivered to drawbar		55 per cent
	100	100

Under unfavorable conditions, such as harrowing plowed ground, the dispersion will be about as follows:

Power of motor	100 per cent	
Loss in transmission		15 per cent
Rolling resistance		50 per cent
Slippage		10 per cent
Delivered to drawbar		25 per cent
	100	100

If the above analyses are correct, rarely more than 60 per cent of the power of the motor is applied to the field machine, and often it is as little as 25 per cent.

During the past three years I have been interested in the development of apparatus for determining tractor wheel efficiency. This apparatus, which has been described by E. V. Collins in a paper read before the Society, furnishes an opportunity to study the input and output of a tractor wheel as it functions independently of the rest of the tractor. The outstanding observation made in connection with this apparatus, which was virtually a mental shock, was the enormous amount of energy required to roll a weighted tractor wheel over loose soil.

Must these conditions always remain so? Will we not be able to find a more efficient way of utilizing mechanical power?

A most promising means of changing this situation is found in the power take-off. The transmission efficiency of this device even when allowing for the friction of the universal joints needed for flexibility, should exceed the transmission efficiency of a tractor, because there is a smaller reduction in speed. Thus it may be correctly stated that the reduction in speed. Thus it may be correctly stated that the efficiency of the power take-off is twice that of a tractor at the drawbar.

If the tractor is so greatly handicapped as a draft motor, would it not be wise to consider the elimination of draft work as far as possible? Is it necessary always to pull an implement in the preparation of a seedbed, or in cultivation to control weeds? Is it proper to suggest that the development of the tractor to date has been largely an attempt to make a mechanical horse and that little attempt has been made either to comply with the inherent characteristics of the gas motor, or to utilize its special advantages, the most outstanding of which is light weight.

There are important problems connected with the mechanical design and construction of the tractor, but from my viewpoint these are secondary to those related to making the gas tractor a more economical farm power plant.

In connection with the survey of research and investigation work in mechanical farm equipment made during the current year for the U. S. Department of Agriculture, it was found that ten of the agricultural experiment stations were conducting investigational work in reference to tractors and that there were altogether fourteen research projects under way. Among the problems suggested, twenty-one problems relating specially to the tractor have been listed in the final report. In addition there were several general farm power problems. Most of these problems related to tractor economics, although there were a few pertaining to mechanical design. This situation indicates the general interest of the experiment stations in tractor development.

It would appear that no group of research problems in agricultural engineering calls for the same amount of cooperation, for the reason that before the gas tractor can come fully into its own the very foundations of a crop production method must be changed.

Removing Dockage at the Thresher*

By Robert H. Black[1]

EXPERIMENTS, conducted by the U. S. Department of Agriculture in cooperation with various manufacturers extending over a period of five years, have proved the economy of cleaning weed seeds out of the grain as a part of the threshing operation, and they have resulted in the development of machines which clean the grain efficiently and economically.

A new type of cleaner has been developed and used during the past threshing season (1926) which is radically different from any cleaner devised previously, either for experimental or commercial grain cleaning. This device consists of an endless rubber belt containing thousands of small pockets which are small enough to hold the kernels of grain but reject the long kernels, such as wild oats and other coarse dockage. The endless belt used during the past season was 5 ft. in width and mounted on an inclined plane.

This cleaner was mounted on a 28-in. separator in the central part of North Dakota and was operated in different kinds of wheat containing dockage as high as 20 per cent. After passing over the cleaner, less than 1 per cent of coarse dockage remained in the wheat in nearly every instance. Much of the wheat threshed was very wet, and threshing conditions were considered unusually bad. Nevertheless the cleaner operated very satisfactorily, and from the experience this year it is evident that the light weight and low cost of the rubber belt will make it attractive to those threshermen who desire to secure an attachment which can be easily placed on the decks of their present threshing machines.

A complete cleaning machine was built during the past winter by one of the cooperating manufacturers who included, as part of the threshing machine, a complete set of grain-cleaning disks. A three-way valve was provided so that the grain could be diverted direct to the wagon without passing through the cleaner. An additional elevator was used to elevate the wild oats and other coarse dockage removed by the cleaner.

The results secured with this complete grain-cleaning threshing machine were very satisfactory both from the operating standpoint of the thresherman and the results secured by the farmers.

It appears from this series of experiments that manufacturers can now include complete grain-cleaning equipment in their threshing machine and combine designs, and that the thresher operators in the spring wheat area will welcome threshing machines containing such equipment, which is capable of separating wild oats and other dockage from wheat, rye and flax when it is threshed.

*Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1926.

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Common Storage for Fruit and Vegetables*

By E. R. Gross[1]

DURING the past few years New Jersey fruit growers have been so much interested in the storage of their apple crops that the author has given some study to the problem. No credit is claimed for research or experimental work. Two sources of information were found to draw from: (1) The experience of growers and (2) available literature.

In 1926 a tour was organized by the specialist in fruit growing at the New Jersey agricultural college. The agricultural engineer was asked to accompany the tour in the interest of the engineering problems of construction and management. The tour proved to be a very concrete lesson to those who were so fortunate as to attend. Several fine storages were seen. The chief results of the trip may be expressed as follows: Even keener interest in common storage houses for apples, more calls for information on storage-house construction and management, and requests that plans be provided by the state college. Plans have been prepared at least to such a degree of completion that they are usable, and a number of storages have been built.

To completely cover the subject would require a discussion of both cold storage and common storage. The interest already referred to centered on common storage, and this discussion will therefore be confined to common storage.

In undertaking to define common storage it is perhaps sufficient to say that probably its outstanding feature is that artificial means of lowering the temperature are not employed.

The cellar is the age-old storage house because normally its temperature is cooler in summer and warmer in winter than outside air. This cellar then gives us the first and primary storage condition—a fairly uniform temperature. However, we find that we may obtain this condition in above-ground structures if properly designed and constructed. The cellar, originally a dugout, provided moisture through its earth floor until modern concrete brought cellar-making to rock bottom. Thus, the old-fashioned cellar provided another important storage condition—humidity. The third great and important storage condition, which was the stumbling block and almost "padlocked" the good old cellar, is ventilation. Here our forefathers were in error. Instead of a living thing of beauty, they seemed to consider the apple as dead, dormant and ready for decay. Hence, it did decay.

Proper operation of a storage must be considered in connection with construction. Indeed construction makes possible the desired method of operation by introducing the factors of control so that we may have proper temperature, humidity and ventilation. Above-ground and cellar storages each have advantages. The cellar is safer from freezing and may be cooler in the fall, while the above-ground storage is easier to ventilate and is very convenient for loading and unloading. The size of the storage will be controlled by the crop and convenience in handling. A very good plan is that of storing the apples on both sides of a driveway. A building 30 ft. wide (outside) will provide a storage space 9 ft. wide on each side of a 9-ft. drive. Some may prefer to build as wide as 40 ft. The length may vary, to suit the grower, from 30 to 100 ft. or more. To provide ample storage space,

*Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Pittsburgh, Pa., October, 1927.

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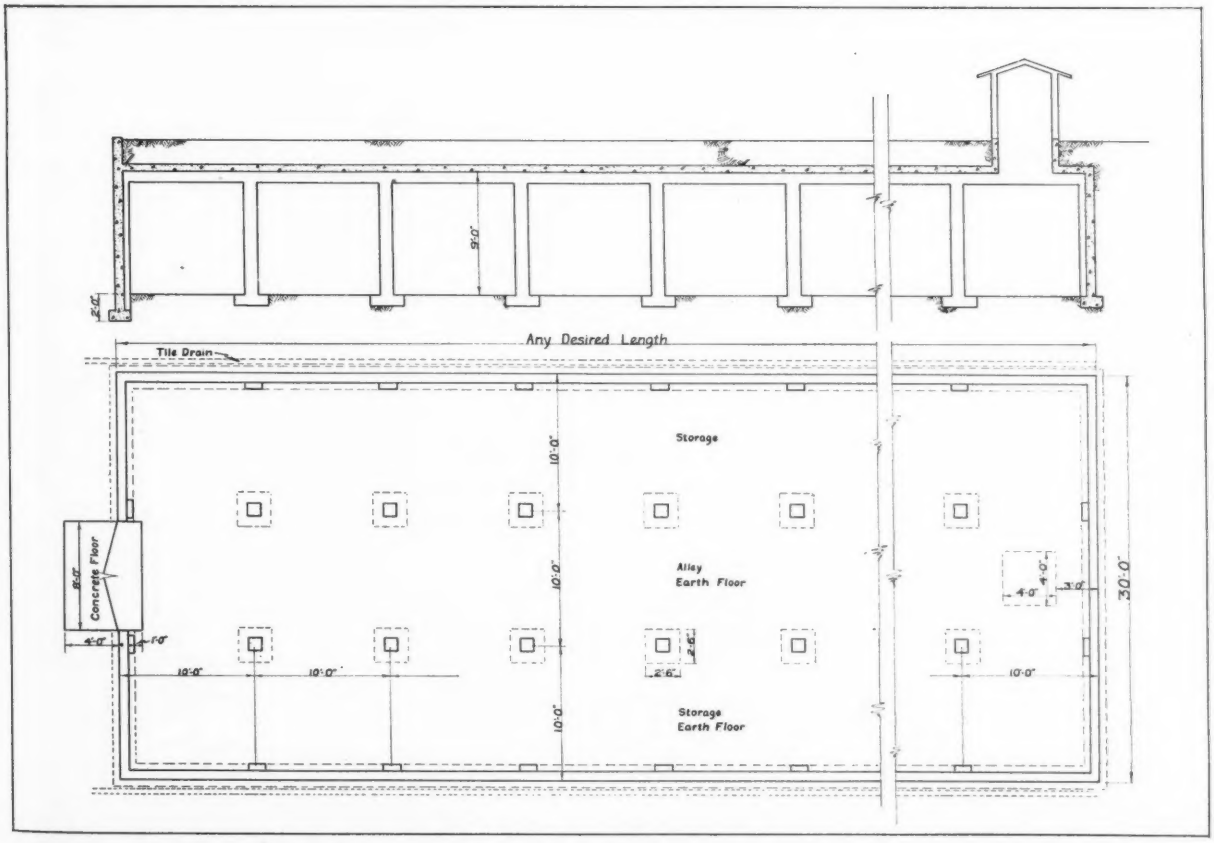

Fig. 1. Floor plan and longitudinal section of a cellar storage having large doors at one end and a large ventilating flue at the other

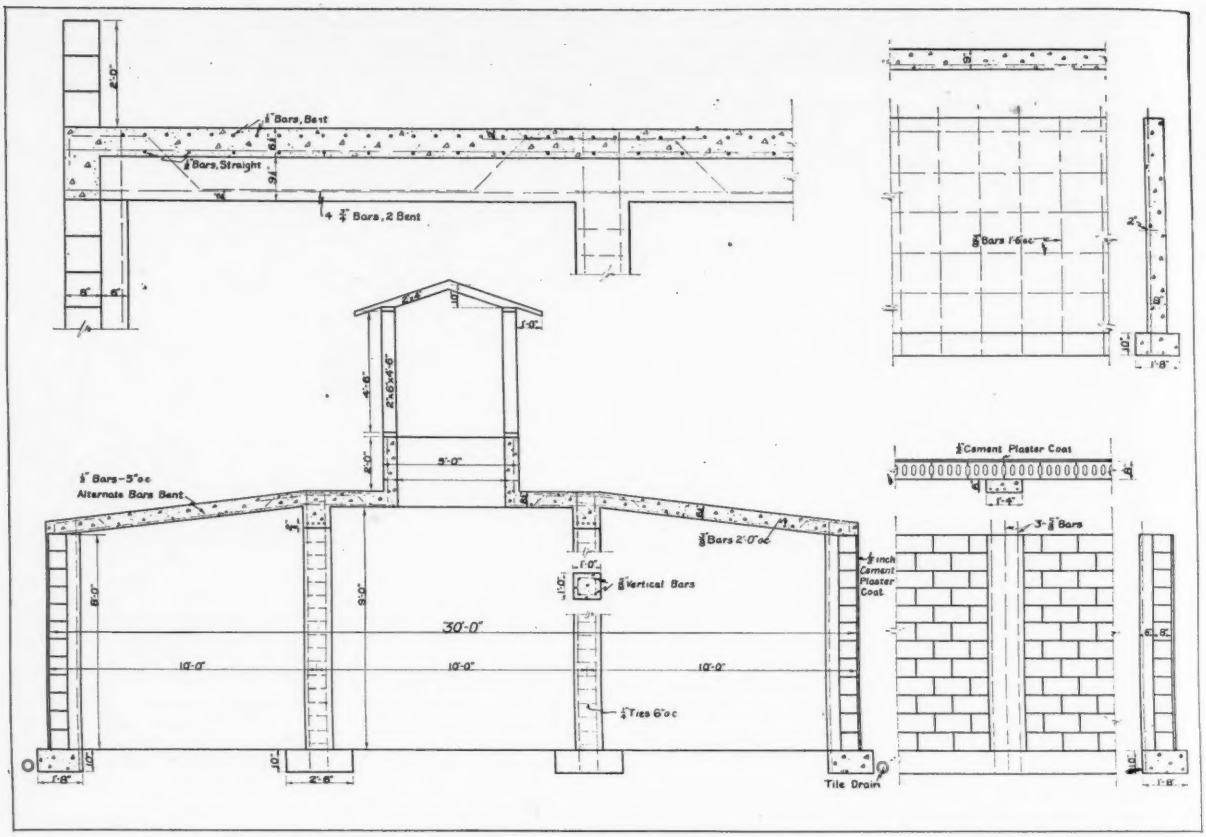

Fig. 2. Cross section and details of construction for cellar storage, showing either reinforced concrete walls or cement or cinder block walls

head room, and air space the ceiling should be 10 to 12 ft. high.

The roof for an above-ground structure may be any desired type. A gable roof is as good as any. For cellars a concrete ceiling covered with 2 to 3 ft. of earth is good. Some may wish to use a gable roof with eaves very near the ground.

An earth floor is usually considered best as it aids materially in controling humidity. A slatted false floor must be used under the stacks of fruit to allow a free flow of air. Concrete should be used only at the entry, so that doors may fit tight at the bottom, and in the driveway. The false floor may be made of 2-by-8-in. lumber supported on 2-by-8-in. stringers spaced 4 ft. apart. The stringers may be built up like horses or they may be supported on concrete blocks. The space for air circulation cannot be overestimated. It is not economy to try to cramp this space.

The fruit is stored in slatted crates or baskets, also to allow circulation of air. The stacks are kept 6 to 8 in. from the walls.

Doorways must be built with care as they must be very tight. Cold storage or refrigerator doors, though expensive, may often be selected. If such doors are not used it is necessary to build double doors, an inner set and an outer set. A vestibule over the door at the sunny side is also necessary to keep the direct rays of the sun from entering the house. The sun shining into an open door may raise the temperature of the house as much as 5 deg. Doors should be 10 by 10 ft., or 10 by 12 ft. to allow easy passage for the truck.

Wire screen, ¼-in. mesh, laid over the earth floor and a few inches up on the walls will keep rodents from burrowing.

Barns, above ground or basement, may be converted into storages by remodeling. A number of good storages have been made in this way. Other buildings, repaired and remodeled in accordance with the principles of construction and management, may also be used.

There is very little difference in the cost of above-ground and cellar storages. The choice will usually be based on other conditions. Where there is a convenient hillside, a cellar may prove very desirable, while on a level farmstead an above-ground structure would be more convenient. Other features of construction are clearly shown in the accompanying plans.

Insulation. In order to maintain proper temperatures the walls and ceiling must be well insulated. Cellar storages are insulated by the earth covering. While concrete, stone or brick are good conductors of heat and very poor insulators, the cellar storages are always moderated by the temperature of the soil. Usually the changes of temperature are within the necessary bounds for apple storage. On the contrary, above-ground storages may heat quite rapidly in summer or cool rapidly in winter. To prevent this the walls are filled or lined with insulating materials. Whatever material is chosen must be used in proper thickness to obtain satisfactory results. The following values are generally assigned to insulating materials:

Values of Insulating Materials Compared

Material	Thickness equivalent to 1 in. of cork board
Granulated cork	1 in.
Celotex	1 in.
Insulite	1 in.
Insulex	1 in.
Cabot's quilting	1 in.
Sawdust	1 1/3 in.
Shavings	1 1/3 in.
Wood	3 1/4 in.
Cinder block	6 in.
Soil (dry)	8 in.
Soil (wet)	48 in.
Hollow tile	12 in.
Brick (dry)	12 in.
Concrete	24 in.
Stone	30 in.

From this table it may be noted that granulated cork, Insulite, Celotex, Insulex and Cabot's quilting are as good as cork board when used in the same thickness, or that it requires 3¼ in. of wood to equal 1 in. of cork. A 24-in. wall of concrete or a 30-in. wall of stone have no more power to retain or exclude heat than has 1 in. of cork.

Experience at the Marble Laboratories, Canton, Pa., shows that 6 in. of granulated cork, protected by building paper and matched lumber on both sides, was sufficient to resist temperatures of 20 deg. below zero for periods of a few days. Insulating materials lose their value when wet. It is highly important to provide proper protection to keep them dry.

The plans which we have prepared are intended to help the New Jersey fruit grower and are not presented with any idea that other and even better ones might not be obtained. There is probably nothing original about them. We acknowledge the origin of the material as stated before.

For the cellar storage concrete or masonry walls seem quite satisfactory and a concrete roof or ceiling certainly has many advantages. For the above-ground structure a 2-by-6-in. studding is used to allow for 6 in. of cork. Good waterproof building paper is used next to the studding and this covered with matched lumber. Care must be taken to close tight at the sills that there may be no loss of cork nor any chance for water to enter. On the inside building paper is very good, but on the outside it is well to use a light grade of composition roofing. The ceiling is also covered with 6 in. of cork.

The roof may be supported by posts as these do not interfere with filling the house. The kind of roofing is not important except that it be kept in repair so the insulating material may be kept dry at all times. Should the insulating material become wet it is almost impossible to dry it while in the walls. It is therefore very important that details of construction be followed with great care. Examination of the table of insulating values shows several materials of equal value with cork. Cost, moisture resistance and ease of placing are factors which must be considered along with insulating value.

Ventilation. Ventilation appears to be a very important factor in operating a common storage. Complete and frequent changes of air seem to be necessary if the fruit is to have good keeping quality. Ventilation is needed to carry away the products of respiration. The ripening processes continue in the fruit during the first 6 or 8 weeks of storage until, reaching a fully mature condition, the fruit will remain for weeks more without deterioration. During this period of ripening the air must be changed almost daily in order to carry away the warm gas-laden air from around the fruit. This explains the need for slatted crates and a floor with wide cracks raised at least 8 in. above the earth floor. All these are intended to provide ample flow of air. Large doors are needed to allow the truck to pass through, but they are also needed for ventilation. In the fall the doors are open throughout the night. Screen doors of ¼-in. mesh may be used to exclude rodents. As the cold weather approaches the period of ventilation is cut down, until in the winter doors are opened only for an hour or two in the warm part of the day and possibly only every few days depending upon the stage of ripening of the fruit. No set rule can be laid down. Under cold storage conditions, or in the winter when the temperature approaches 32 deg., respiration almost ceases. There is then less need for ventilation.

It is not wise to crowd the storage. A space of 6 to 8 in. should be left at the walls. This allows air movement in ventilating and affords protection against possible frost, for the wall is the coldest part of the building. A free air space at the walls will maintain a more uniform temperature throughout the storage. Half or 5/8-bu. baskets, bushel hampers, baskets with slatted bottoms, or better still bushel crates, should be used for storing the fruit. Neither closed packages nor pouring the fruit in bins are advised for common storage. They do not usually allow a sufficient flow of air to thorough-

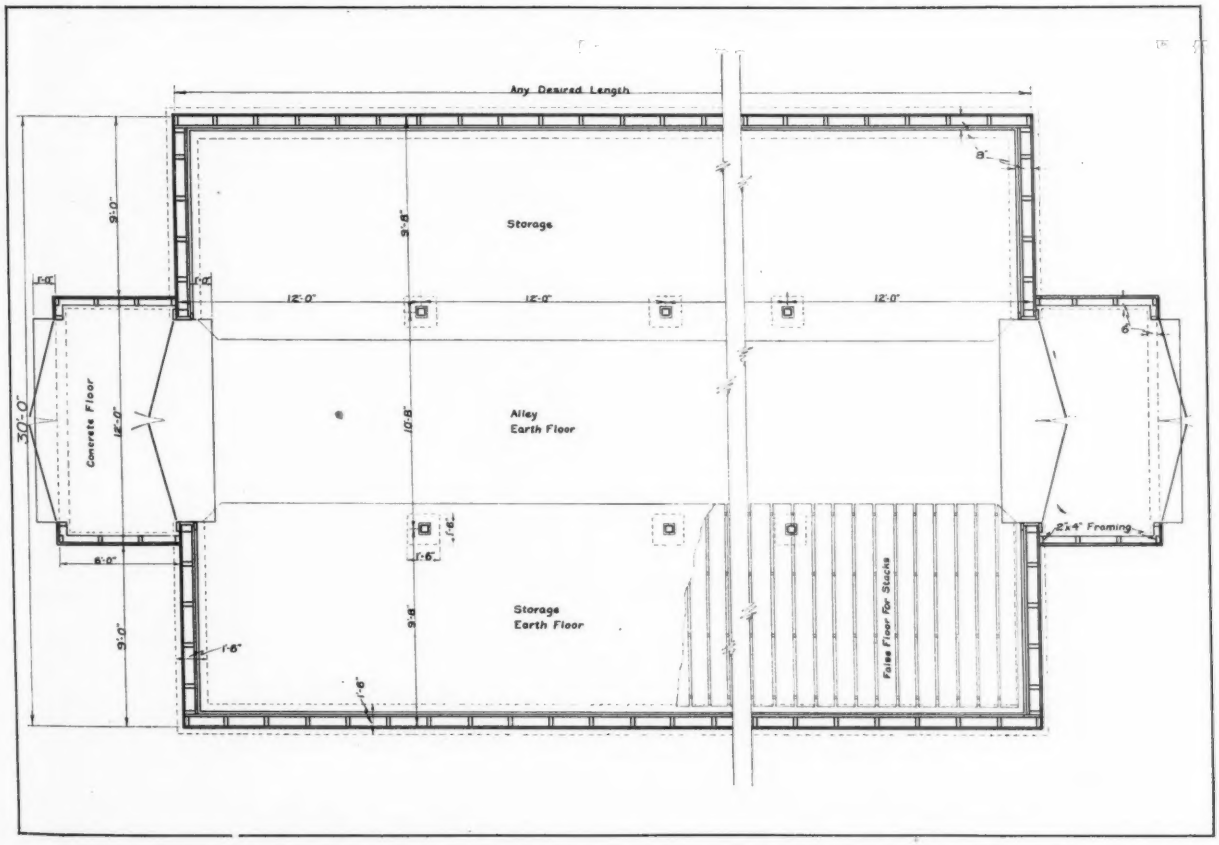

Fig. 3. Floor plan of an above-ground storage, framing construction insulated by filling the walls with granulated cork

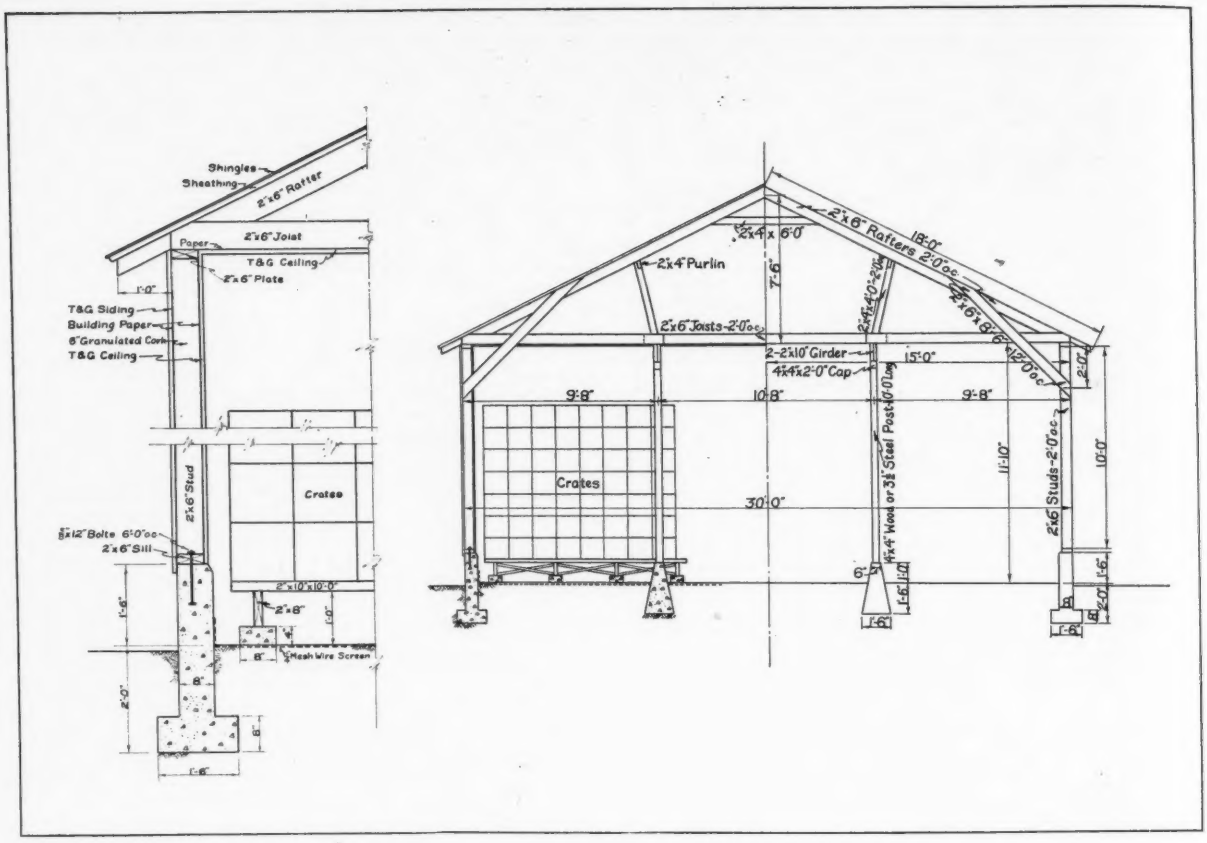

Fig. 4. Cross section and framing details of an above-ground storage

ly ventilate the fruit. Scalding and rapid deterioration are the result.

Humidity. High humidity is desirable to prevent shrivelling of the fruit. A humidity of 85 to 95 gives best results. An earth floor, which may be sprinkled when necessary, is a very good regulator of humidity. While tubs or troughs of water have been used to advantage, sprinkling either earth or concrete floors is considered more satisfactory. Humidity cannot be neglected if good results are to be obtained. In any storage which is not naturally damp it seems wise to provide some means of reading the humidity. There are three instruments, any of which may be used to check the humidity. The self-recording hygrometer gives a continuous record of humidity and is read directly. The sling psychrometer or the wet-and-dry-bulb thermometer (Mason hygrometer) afford means of calculating humidity or reading it from tables provided with these instruments.

Temperature. There seems to be some diversity of opinion as to proper temperatures for keeping apples. In common storage low temperatures are not often obtainable in the early fall. Yet apples have been kept in very good condition in such storages. Fruit may be kept in good commercial condition for long periods with good ventilation and humidity even though the temperature is near 75 deg. This is not a desirable temperature and best results will be obtained only by close watch of the ventilation and humidity. Every advantage should be taken of the coolness of night to lower the temperature. Fruit should not be stored during the heat of day, but whenever possible should be allowed to cool over night before being placed in the storage. High temperature hastens the ripening of the fruit. It may be desirable therefore to use a pressure tester in determining the state of preservation or the need for early marketing.

Weeds Hamper Use of the Combine

THE weeds found in spring-sown wheat present the principal drawback to the use of the combined harvester-thresher in the four principal spring wheat states of North Dakota, Montana, South Dakota and Minnesota. These weeds contain high percentages of moisture at the time the grain is cut with a combine, and unless the weed seeds are immediately removed from the grain, the grain is liable to heating and serious damage. The moisture in the weed seeds rapidly transfers to the wheat after cutting, causing a lowering in the test weight of the wheat, with a consequent lower price.

A laboratory equipped with the latest and most efficient grain-grading apparatus was established last summer on a large farm at a central point in the spring wheat area by the grain investigations office of the U.S.D.A. Bureau of Agricultural Economics. Samples were taken hourly from the combines in the field and at regular intervals from the combined grain in the storage bins. Robert H. Black, of Minneapolis, who had charge of the laboratory, reports that the test weight, moisture and damage are the principal controllable factors of market value in combining spring-sown wheat. Moisture and test weight can be controlled by not cutting before about eleven o'clock on average days, and by immediately removing all of the weed seeds from the wheat. Damage to the grain can be prevented by proper time of cutting, immediate cleaning and proper storage. If wheat must be cuts when it contains over 14 or 14½ per cent of moisture, it should be immediately cleaned and placed in a well-ventilated bin. Every spring wheat farmer operating a combine should either own or have access to a moisture tester.

Electrically Heated Dry Air Sterilizers*

By A. W. Farrall[1]

DRY hot air seems to offer certain advantages as a medium for the sterilization of dairy equipment. It has been extensively and successfully used in connection with the sterilization of surgical and laboratory instruments for some time.

It is likely that the opinion, that heat in the presence of moisture is more effective as a destructive agent of bacteria than "dry heat" at the same temperature, has led to the almost universal use of steam for the sterilization of dairy equipment. The use of dry hot air for sterilization has also been retarded on account of difficulties in the construction of a steam or gas-heated dry-air sterilizer. The development of electric-heating elements which can be placed directly in the air to be heated has greatly improved and simplified the matter of construction.

Dry hot air has the following advantages, which recommend its use:

1. Depreciation of equipment should be less on account of absence of moisture.
2. Greater economy should be obtained since the air is of low specific heat and heat is not required for vaporizing water as in the case of the steam type sterilizer.
3. There should be less danger of burning out heating elements, since they are made to operate in air and thus are not dependent upon being submerged in liquid.
4. Absence of moisture would make for more sanitary conditions about the sterilizer.
5. Equipment should remain sterile longer than when using steam, since it is left dry. Bacteria do not multiply rapidly on dry clean surfaces.

Comparatively little work has been done by investigators concerning the use of hot air for sterilizing dairy utensils, although as early as 1881 Koch and Wolffhugel showed that certain pathogenic bacteria were destroyed by heating to a temperature of 212 deg. F. for 1½ hr. Other investigations showed that much higher temperatures are required with "dry heat," than with "moist heat" for the same bacterial-reduction efficiency. Ayers and Mudge found that it was necessary to maintain a sterilizer temperature of 230 deg. F. for 30 min. in order to sterilize satisfactorily with dry air. They found that in a gas-heated sterilizer it was necessary to circulate the air by means of a fan in order to obtain good results. Their apparatus, however, was a type which did not induce natural convection currents to a great extent.

In order to study the use of hot air for sterilizing, a four-can-capacity, oil-heated sterilizer similar in design to one used in the study of oil-heated sterilizers was built. The lower half was insulated with a double-walled air space, and an air heater was assembled and placed in the trough in the bottom of the sterilizer; a number of heaters were tried but the most satisfactory is shown in Fig. 1, placed as shown in Fig. 2. This heater had a large radiation surface and induced good convection currents. It was found necessary to partially cover the heater with metal baffle plates as shown in Fig. 2 to prevent direct radiation of the heat to the bottom of cans and thus prevent localized overheating.

Temperatures were measured by means of chemical thermometers inserted through holes in the side of the sterilizer. One thermometer was placed in a pocket in the side of a milk can, for the purpose of measuring the temperature of the can metal.

The electrical energy input was measured by means of an indicating wattmeter.

The load was 60 lbs. of dairy equipment consisting of two 10-gal. milk cans and one tubular milk cooler.

Sterilization temperature was considered as being 230 deg. F. or above.

Time and Temperature Characteristics. Fig. 4 shows the time and temperature characteristics of the hot-air sterilizer as measured at the center of the sterilizer when using 2120-watt and 3290-watt elements, respectively, and with no equipment being sterilized. Curve No. 1 shows that with the 3290-watt heater a temperature of 230 deg. F. was reached at the end of 6 min. and 300 deg. F. was reached at the end of 16 min. The 2120-watt element (see Curve No. 2) required 16 min. to reach a temperature of 230 deg. F. and 47 min. to reach a temperature of 276 deg. F. The sterilizer cooled off very rapidly as shown in Curve No. 1 where the temperature dropped from 300 to 230 deg. F. in 4 min.

It is apparent that the hot-air sterilizer is quickly heated with only a small element and with a small amount of energy; also that it cools off quickly after the source of heat has been removed.

Uniformity of Heating Inside the Sterilizer. Fig. 5 shows typical time and temperature curves plotted from data taken at three places inside the sterilizer. The thermometers were inserted through holes in the sides of the sterilizer in the same position and manner as mentioned in previous articles on oil-heated sterilizers.

It is apparent that the temperature of the sterilizer air is greatest near the center of the top. Here the temperature reached 230 deg. F. in 20 min. under load and went to a maximum of 298 deg. F. at the end of 4.4 min. Under the same conditions the temperature near the side and end reached a maximum of 212 deg. F. at the end of 44 min., at which time the power was turned off. The temperature at the end and bottom of the sterilizer reached 192 deg. F. as a maximum at the end of 44 min. It is evident that there is a great

*Last of a series of four articles on the characteristics of dairy equipment sterilizers, based on the results of investigations conducted at the University of California. The three previous articles of this series appeared in the June, September, and October (1927) issues of AGRICULTURAL ENGINEERING.

[1]Junior agricultural engineer, University of California. Assoc. Mem. A.S.A.E.

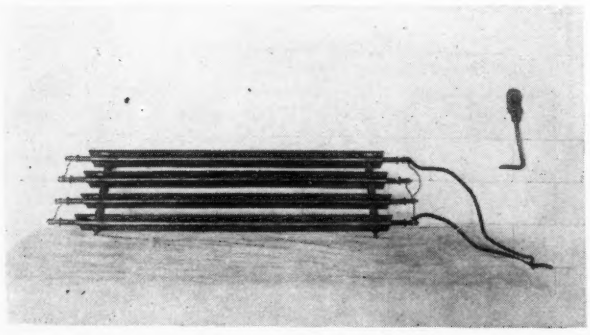

Fig. 1. Electric air heater, built up of four 500-watt fin-type heating elements. Note that this type of heater has a large radiating surface per watt of energy consumed

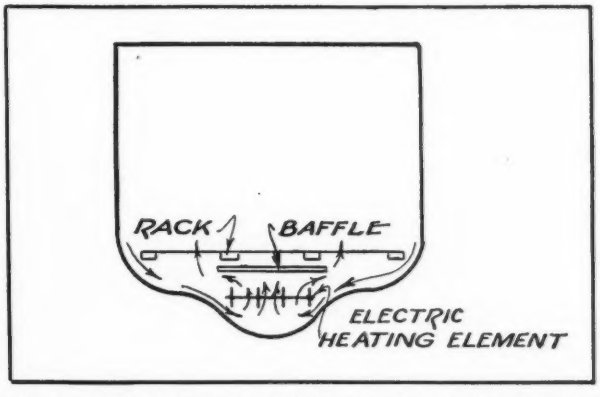

Fig. 2. Section of hot air sterilizer, showing placing of heating element and baffles, also circulation of air

temperature variation in different parts of the sterilizer, being a maximum of 106 deg. F. This shows that there is danger of poor sterilization of small parts which happen to be in the bottom of the sterilizer, or near the outside of the sterilizer.

Temperature of Can with Respect to Sterlizer. Fig. 5 also shows the temperature of the metal of the can with respect to the sterilizer temperature. Can temperature was measured by means of a thermometer installed in an oil pocket soldered to the side of the top of the can. It is evident that there is a considerable lag of the can temperature, for in this particular series the can reached a temperature of 230 deg. F. at the end of 33 min., while the top of the sterilizer, adjacent to the can, reached the same temperature at the end of 21 min. Note should be made that the temperature in other parts of the sterilizer was much lower than in the can. Other tests showed that the rate of lag of the can temperature was proportional to the speed of heating. Thus with a 3,000-watt element the maximum was 70 deg. F. instead of 50 deg. as when using the 2,000-watt heater. Slight variations in the rate of heating were found when the equipment was rearranged in the sterilizer. It is significant that the can temperature decreased at a slower rate than the sterilizer temperature after the power was turned off, providing the sterilizer cover was left in place.

With certain preliminary designs in which heaters that were too large were used and in which air circulation was poor, the cans were overheated in spots and some of the solder melted.

Bacterial Reduction. Table I shows also the bacterial reduction efficiency as determined by inoculating 10-gal. milk cans with bacteria to a degree such that the count was over 1,000,000 per cubic centimeter of a 400 cc. water blank used in making tests. After sterilizing at a temperature of 230 deg. F. and above, as shown in the table, the bacterial count was reduced to a minimum of 4.5 bacteria per cubic centimeter and a maximum of 17.5 bacteria per cubic centimeter. The cans before the test were merely rinsed and not thoroughly washed, thus making the conditions more severe than would ordinarily be found in practice.

Milk cans and equipment were dry after sterilization, especially if the cans were inverted in the sterilizer. Some moisture was left, however, at times, if the cans were sterilized right side up. All exterior surfaces of the equipment were left dry.

Table I shows results obtained in a number of series of tests in which a two-kilowatt heating element was used in connection with a four-can size sterilizer containing 60 lb. of equipment. The average amount of energy used was 1.70 kw.-hr. per batch which, at 2.5 cents per kilowatt-hour would cost 4.25 cents. The minimum was 1.60 and the maximum 1.84 kw.-hr. which would cost 4.0 and 4.6 cents, respectively.

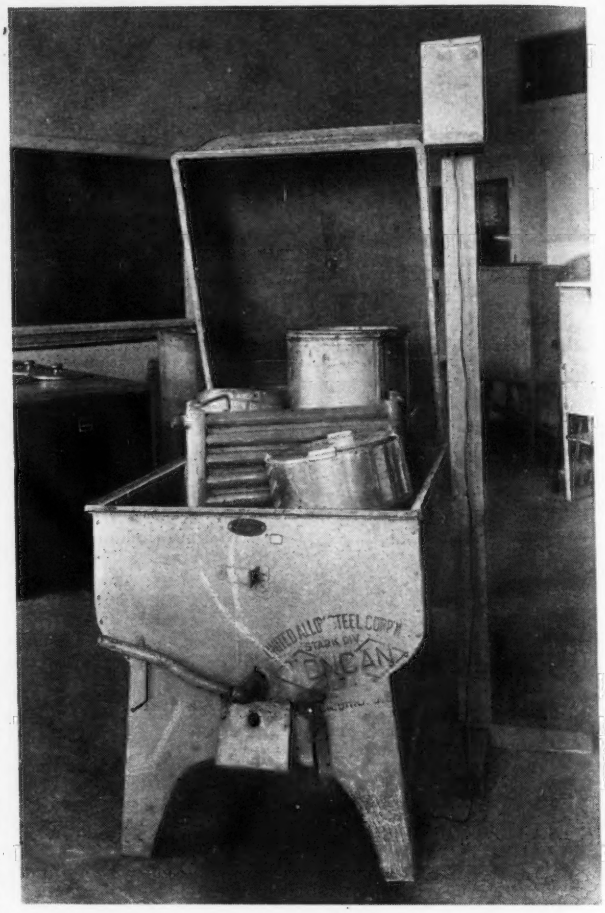

Fig. 3. The experimental sterilizer was of the type shown above, but with the oil burner removed and an electric heating element installed in the bottom of the tank

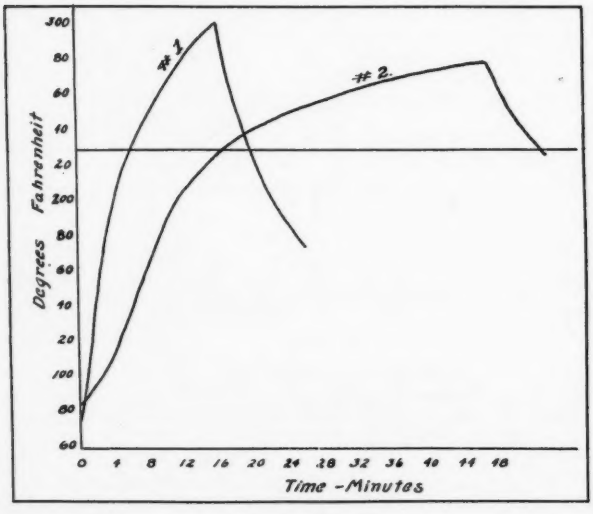

Fig. 4. Time and temperature curves for hot-air type sterilizer with 3290-watt (Curve No. 1) and 2120-watt (Curve No. 2) heating elements. Sterilizer capacity—four 10-gallon milk cans. Sterilizer load—none

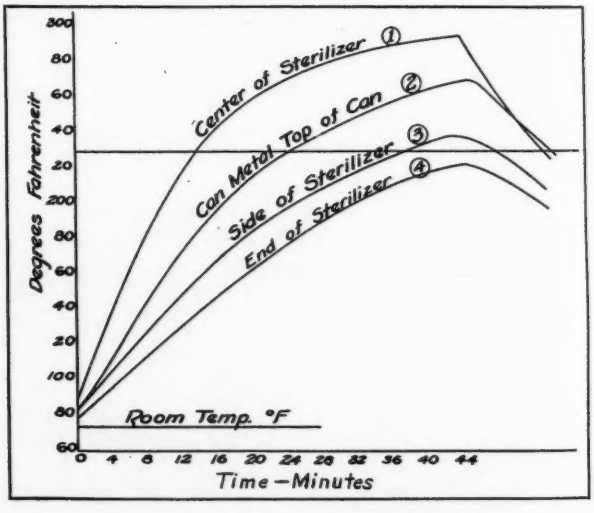

Fig. 5. Curves showing variation of temperature inside a four-can, hot-air sterilizer, using a 2190-watt heating element. Sterilizer load—60 lb. of equipment

TABLE I. Performance of Four-Can Capacity Dry-Air Dairy Equipment
Sterilizer (Load—60 lb. of Equipment)

Series No.	Room temp. —deg. F.	Maximum temperature—deg. F.				Watts demand	Kw.-hr. per batch	Time—minutes						Bacteria count* after sterilization	Cost in cents per batch-energy, 2.5 per kw.-hr.
								Sterilizer		Can					
		Sterilizer center	Can top	End sterilizer	Side sterilizer			To 230 deg. F.	Above 230 deg. F.	To 230 deg. F.	Above 230 deg. F.	Current on	Total time of test		
1	75	294	270	223	238	2190	1.60	14	40	24	30	44	54	10.0	4.0
2	66	302	281	218	237	2130	1.84	21	41	28	34	52	62	4.5	4.6
3	72	316	266	236	197	2268	1.66	13	39	28	25	44	54	17.5	4.1
4	72	278	271	216	228	2256	1.73	16	38	27	26	46	54	8.0	4.3
Average	71.2	297	272	223	225	2211	1.70	16	39.5	26.7	28.7	46.5	56	10.0	4.25

*The bacteria count before sterilization was, in each case, over 1,000,000.

SUMMARY

1. Satisfactory bacterial reduction in milk cans may be obtained by sterilization in hot air at 230 deg. F., or above, for 30 min. in a small four-can-capacity sterilizer, providing a good circulation of air is obtained in the sterilizer.

2. Dry hot-air sterilizers, depending upon natural convection currents for carrying the heat, have considerable temperature variation throughout the sterilization compartment when loaded with utensils and especially when heated rapidly. The temperature variation was not great when no utensils were in the sterilizer to interfere with convection currents.

3. The proper and most efficient place for the heater is in the center of the bottom of the sterilizer, in order to assist in setting up natural circulation. It was found desirable to place baffles directly over the heating elements in order to prevent localized overheating of the equipment due to direct radiation. They also assisted in the formation and direction of convection currents.

4. Tests with various sizes of elements showed that a 2-kw. heater was about the right size for use with a four-can sterilizer. This heater brought the sterilizer to a temperature of 230 deg. F. in from 15 to 20 min. and could be turned off after about 45 min. of operation. The maximum temperature reached was about 300 deg. F. When using a 3000-watt or larger element the temperature quickly went above 300 deg. F. and resulted in melting the solder on the utensils. Elements smaller than 2000 watts did not bring the temperature to the proper point, although they would probably do so with an insulated sterilizer. The energy required per batch of 60 lb. of equipment averaged 1.70 kw.-hr., which at 2.5 cents per kilowatt-hour would cost 4.25 cents.

5. The use of electrically heated dry-air sterilizers seem to be desirable and practical in many cases since it destroys bacteria satisfactorily; it leaves utensils dry after sterilization, and it is less expensive than when using steam. Electricity seems to be a very satisfactory means of heating the air. A further advantage is that the air heater is less expensive than the water heater and is less liable to burn out as there is no danger, even though the operator does neglect to turn off the power when he is through sterilizing.

6. The successful electrically heated dry-air sterilizer should be so constructed that it brings the temperature of the sterilizer and equipment to the proper point quickly and yet not cause localized overheating. Overheating may be prevented by proper circulation of air, either through natural convection currents or by fans (recommend in large sterilizers) and by preventing direct radiation of heat to the equipment. The heating elements should be of low wattage per unit area and should be so set as to induce maximum air currents. Care should be taken to make sure that the elements are properly insulated in order to withstand the high temperature present. The sterilizer box should be properly insulated against heat loss. Thermostatic control with elements that are cut in and out as needed would be desirable.

The Use of Artificial Lighting to Increase Winter Egg Production

By J. E. Dougherty[1]

THE use of artificial lighting to increase the winter production of laying hens is of American origin. In winter the hours of daylight are short as compared with summer and the weather is colder. More food is, therefore, required to maintain the body heat of the hen yet fewer hours are available in which food can be consumed. The normal capacity of a hen's crop being limited, she cannot fill it during the winter months with much more than enough food to nourish her body during the long night hours, very little is left to be manufactured into eggs.

Data compiled from sunrise and sunset tabulations supplied by the San Francisco office of the U. S. Weather Bureau for meridian 120, for example, show the average hour of sunrise between October 1 and March 1 to be about 6:59 a.m. and the average hour of sunset to be about 5:18 p.m. The difference, therefore, between the average hour of sunrise and the average hour of sunset for this period is 10 hr. and 19 min.

It is generally conceded that artificial lighting should be used to lengthen the "working" day of the hen to not less than 12 hr. and not more than 13 hr. A laying hen should not need any more rest in winter than in summer, and the only reason for her spending more time on the roosts in winter is that there are more hours of darkness. Experiments and practical experience prove that the judicious use of artificial lighting is not in any way injurious to the hen's well-being. It simply tends to stimulate winter production by increasing the number of hours in which she can see to eat and exercise. It cannot stimulate or force in the sense that a drug does and should be equally beneficial to laying stock of any age. A flock may lay poorly in spite of artificial lighting, but not because of it.

The use of artificial lighting in California may begin as early as October 1 and should be discontinued in the spring when day breaks sufficiently to render lights of no further value in stimulating production. In trials it has been found that the natural stimulus on production due to the opening of the breeding season and the lengthened period of daylight makes artificial light of practically no value after March 1.

The consensus of opinion among poultry keepers is that artificial lighting in winter should be employed only on layers used to produce market eggs and not on breeding hens. It is held that, if the breeding hens are not induced to produce heavily for a considerable period preceding the hatching season, better hatches and more vigorous chicks will be obtained.

In employing artificial lighting, sufficient illumination should be supplied to amply light the mash hoppers and

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scratching floor so that the birds can readily see to eat and scratch. The size and interior arrangement of the house will determine how best to locate lights for most effective results and properly designed reflectors will greatly improve the concentration of light toward the floor where it is needed.

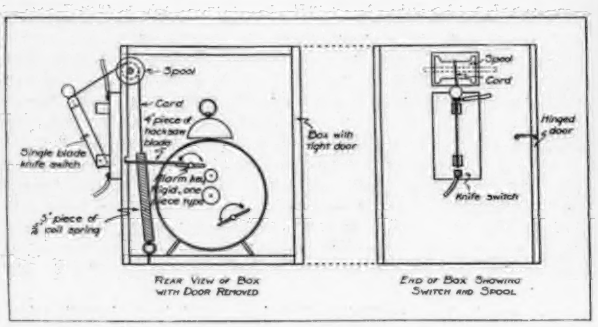
In order to determine the relative efficiency of two types of reflectors a night test was made in a pen 18 ft. deep and 20 ft. wide, with a shed roof and with 6-ft. droppings board against the rear wall. One was a homemade tin reflector 16 in. in diameter and 4 in. deep. The other was factory made and known in the electrical trade as a No. 75 12-in. R.L.M. dome reflector. It was green enameled outside and white porcelain enameled inside. One of the factory made reflectors containing a 100-watt-lamp frosted inside and hung in the center of the floor space in front of the droppings board at a distance of 7 ft. above the floor proved more efficient than two homemade reflectors using 50-watt, clear, mill type lamps equally spaced over the same floor area at a height of 6 ft.

Below are given the foot-candle meter readings for the two types of reflectors. As reported by the New York (Cornell) Agricultural Experiment Station (Agricultural Extension Bulletin 90), 0.8 foot-candle of illumination is necessary to enable fowls to see well enough to scratch feed out of the litter and eat mash. In this test one R.L.M. reflector using a 100-watt lamp was sufficient to give 0.8 foot-candle or more of light over all parts of the floor in front of the droppings board, whereas with two homemade reflectors, each containing a 50-watt lamp, the floor areas near the side walls and toward the rear of the pen received less than 0.8 foot-candle of illumination, and the intensity elsewhere was less than with the dome reflector.

	Foot-Candle Readings	
	No. 75 12-in. R.L.M. reflector	Home-made reflector
On floor directly beneath reflector	8.0	5.0
On floor at side wall close to front wall	1.0	0.8
On floor at side wall below front edge of droppings board	0.8	0.5
On floor beneath droppings board and near rear wall where area of illumination ended in a sharply defined deep shadow	0.5	0.35

The line of separation between lighted area and sharply defined shadow was 20 in. from the rear wall when the R.L.M. reflector was used and 8 in. when the homemade reflectors were used. This was due to the fact that the homemade reflectors were hung 1 ft. lower than the R.L.M. reflector. The latter, on the other hand, illuminated the roosts much better.

The R.L.M. reflector at a height of 7 ft. gave a more effective illumination of the pen for the same consumption of electricity than the two homemade reflectors at 6 ft. (as recommended by the Cornell station), and being a foot higher was more out of the way and less subject to damage. The cost of installation would probably be about the same for either reflector as the price of the R.L.M. reflector would about equal that of two homemade reflectors and one more lamp and socket.



A simple homemade time switch

The use of lights in the morning only has been shown experimentally to be equally as effective as night lighting, or the combination of both morning and night lighting, and it has the advantage over night lighting of obviating the necessity of dimming the lights to get the birds on the roosts. If night lighting is used, however, a simple method of dimming the lights is to run three wires through the building. The bright lights are then connected in parallel to the center wire and one outside wire, and the dim lights to the center wire and the other outside wire, the dim lights being fewer in number or of much lower wattage, or both. With a snap switch cut into each of the outside wires, the opening of one switch and the closing of the other will operate either set of lights depending on which switch is opened or closed. Another method is to cut in a resistance coil of proper size around a secondary switch located between the lights and main switch. Closing the secondary switch will cause the lights to burn brightly; opening this switch forces the current through the resistance coil and dims the lights.

Time switches, which will turn the lights on and off automatically at the desired times, can be purchased at very reasonable prices and at higher prices there are switches which will dim the lights as well as turn them on and off. But for night lighting the switches can be readily operated by hand.

In the accompanying drawing is shown an inexpensive homemade switch which will turn the lights on but will not turn them off. When morning lights are used, this clock will turn them on and the poultryman can turn them off by hand.

When lighting is begun in the fall, the lamps are usually lighted 15 min. before daylight the first few days, and then the time is advanced by 15-min. intervals twice a week till the time is reached at which they are to be regularly turned on. In spring they are gradually discontinued in the same way.

Since the effectiveness of artificial lighting is due primarily to feeding and exercise, best results cannot be expected unless the poultry keeper feeds his hens to best advantage. Extending the working day without keeping the hens busy eating and scratching cannot be expected to bring results. Bringing them off the roost at 4:30 a.m., the coldest part of the day, without having grain in the litter for them to scratch out so that they will be kept warm through food and exercise and not sit huddled together in corners, will not prove of much value.

AUTHOR'S NOTE: The author is indebted to H. L. Belton and J. P. Fairbank, of the division of agricultural engineering, University of California, for their assistance in testing the relative efficiencies of the reflectors mentioned in this paper.

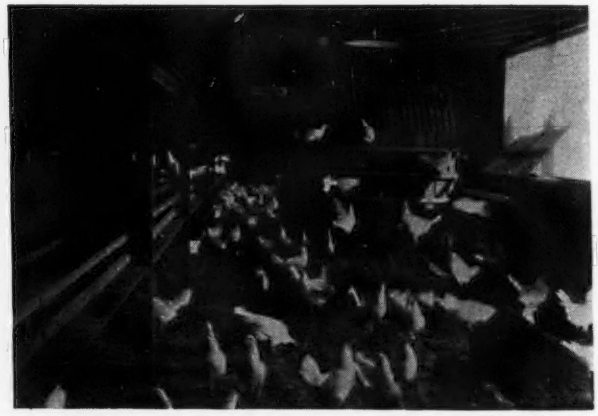


Fig. 2. This picture shows a modern installation of electric lights in a California laying house. (Courtesy of R. B.Casson, Puritan Poultry Corp., Atascadero)

Electrical Service for Rural Districts*

By J. W. Purcell[1]

Part 2. Design of Rural Distribution Systems

(Continued from the November issue)

THE standard (primary) circuit for distribution from the substation is four-wire, three-phase, 4,000/2,300-volt, star-connected, with the neutral wire grounded; the frequency is 25 or 60 cycles according to that of the generating system. One, or more if required, of these three-phase circuits, is taken out of the substation and carried into the rural district.

The extent of the three-phase circuit in any direction is determined by the amount of power to be distributed in that section. It is extended as far as is required to secure the desired voltage regulation, and no further. This limitation of the three-phase circuit, with resultant economy, is feasible because three-phase service is not offered to the individual consumer except for exceptionally large loads. In practice, the three-phase circuit forms approximately one-third of the total length of circuit; located along the main highway it constitutes the backbone of the distribution system and from it, at each intersecting cross road, are carried single-phase, 2,300-volt branch circuits, connected in rotation to the three phases of the main circuit. One conductor of the single-phase circuit is grounded. Connections to the ground are made at the substation and at each service transformer, these being required on the average at about ¼ mi. apart. The area served from one substation is usually limited to approximately 100 sq. mi. Recently, to cope with special circumstances, departures from the standard circuit have been made in certain cases.

The Secondary or Service Circuit. Adjacent to or on the property of the consumer a transformer is installed in order to reduce the voltage from the 2,300-volts of the primary circuit to the 220 or 110 volts for the service circuit. For safety it is found desirable to avoid carrying the 2,300-volt circuit on to the property of the consumer, and, therefore, this circuit is confined to the highway unless the consumer's buildings are situated at an unusually great distance from the highway.

Single-phase, 110-volt service is supplied for the use of consumers having an average lighting load; 220/110-volt, three-wire, single-phase service is supplied for consumers with electric cooking ranges or motors of 2, 3 or 5 hp. Upon the average farm larger demands are uncommon, although occasionally it is found advisable to provide three-phase, 220-volt service, and in exceptional cases, three-phase, 550-volt service.

Overhead Line Construction. The distances between consumers along the highway in the country are, of course, much greater than in the cities, and consequently the length and therefore the cost of line per consumer and also the cost of operation and maintenance is likewise greater.

It is, therefore, essential to install a type of construction having low capital cost in order to obtain such rates as will be attractive to the farmer. On the other hand, the construction must be mechanically strong for safety in order to avoid interruptions to service and to keep down maintenance costs. The electrical characteristics of the conductors and equipment must be ample because the farmer will not be content with a quality of operating service inferior to that supplied in the towns.

All such conditions have been given due consideration in the design and construction of the lines standardized by the Hydro-Electric Power Commission of Ontario. To a large extent, the Commission's experienced construction force is supplemented by local labor, thus reducing the cost of transporting laborers from place to place and the cost of the lost time involved in so doing. The farmers themselves are willing to engage in the work, appreciating the fact that a reduction in the cost will be reflected in the rates, because the power is sold at cost. Competitive tenders also are received from contractors and some work is done on contract basis.

Lines are Built on the Highways. Farm dwellings and barns are usually placed reasonably close to the highways and lines on the highway are therefore conveniently situated for the connections to the farm buildings. Trees form perhaps the greatest obstacle to these lines, although telegraph and telephone poles are commonly encountered. The use of the telephone is very general in rural districts in Ontario, and telephone lines are frequently found on both sides of the highway. In a few cases arrangements have been made for the joint use of poles for telephone and power wires. Where the poles of a power-transmission circuit of higher voltage have already been erected along the highway, such poles are used for the support of the conductors of the rural circuit, thereby avoiding duplication of poles. Occasionally the poles are placed on private property just inside the line fences, in order to avoid excessive trimming of large trees or the installation of unusually tall poles.

The standard pole used is of eastern Canada cedar and is

*Parts 2 and 3 of a paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Pittsburgh, Pa., October, 1927. (Part 1 appeared in the November issue of AGRICULTURAL ENGINEERING.)

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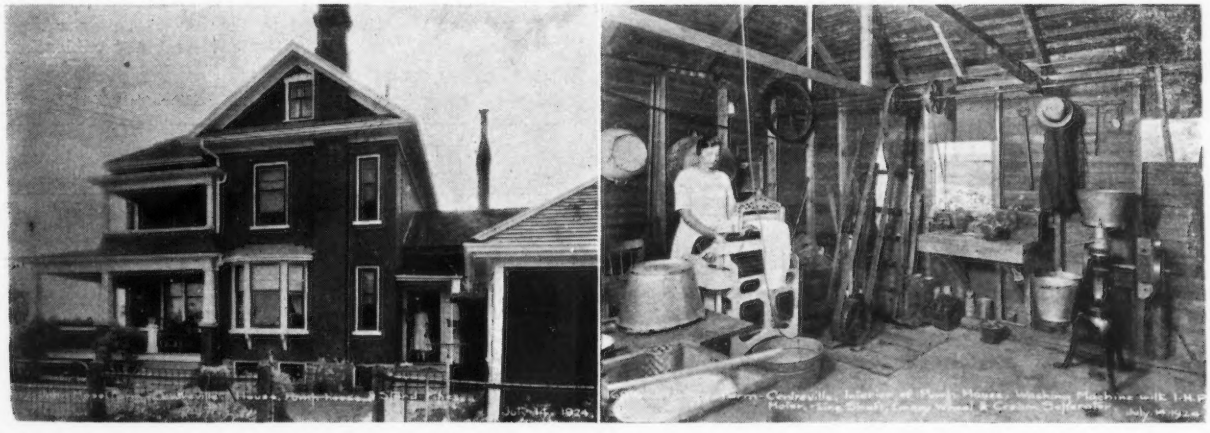
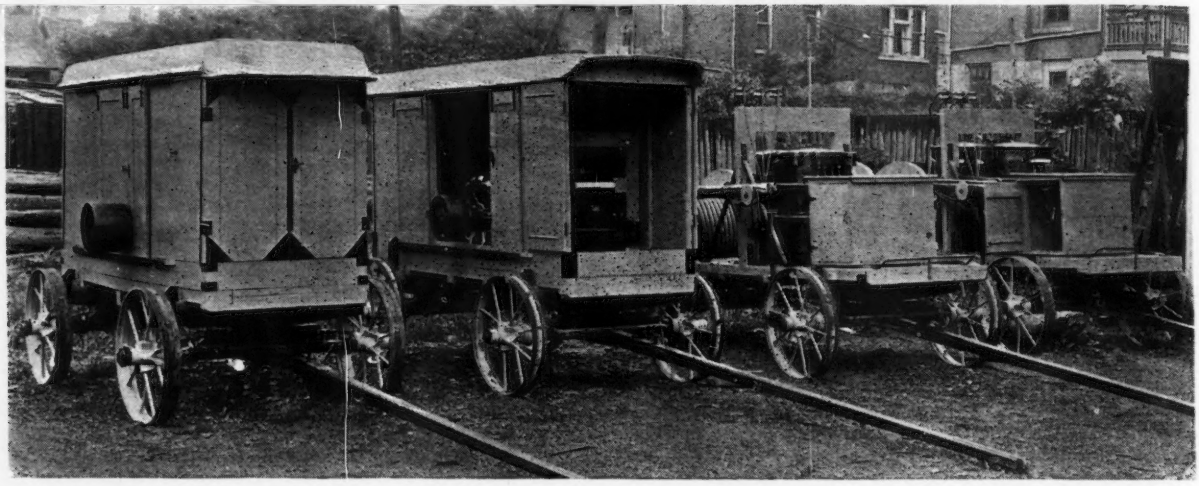


(Left) Farm house on the John Moss farm in Ontario supplied with electric service by the Hydro-Electric Power Commission of Ontario. (Right) Interior of the pump house on the same farm. To the lineshaft are belted a pump, double-head emery wheel, cream separator and a grindstone which is used outdoors. The total annual consumption of electric current on this farm is 2,450 kw.-hr. and the net bill is $105.66



Syndicate or commercial outfits are used in a number of rural districts, served by the Hydro-Electric Commission of Ontario, for the heavier power needs such as silo filling, threshing, and cutting wood. One unit consists of two wagons; on one is mounted the motor and starter and on the other the transformer; secondary and primary cables, primary switch and metering equipment. Syndicates of the type shown in the picture, where the operator has to handle primary current in making connections, are not now being advocated by the Commission. But there are many cases in the province where more than one farm is served from a transformer, and the Commission is endeavoring to have farmers who have this sort of installation consider forming a syndicate for the purposes of heavier work, using motor equipment of such size as may be supplied from the transformer installation which is ordinarily required for the type of contracts that are being served. In some cases there is at present under consideration the advisability of taking two motors to one place and combining the drive in such a way as to have 10 hp. capacity by using the ordinary motors in use on the place—in the case of silo filling belting the two to one ensilage cutter and in the case of threshing separating the drive of the thresher by putting part of the equipment on one motor and the balance on the other

30 ft. in length, with a diameter at the top of 6 in. The standard spacing on tangents between poles is 160 ft., and this spacing is commonly obtained.

Conductors. For the primary circuit, bare hard-drawn copper is used, the cross-section of which must not be less than No. 6 B. & S. gage. This minimum is determined for reasons of mechanical strength and not on account of electrical conductivity. To an increasing extent stranded aluminum conductor with steel core is being used for the primary circuit. This type of conductor permits the lengthening of the span between poles with a decided reduction in the cost of the line. The standard for such construction is 250 ft., and the minimum size conductor is No. 4 B. & S. gage. Where a secondary circuit is required intermediate poles are placed providing spans of 125 ft.

In hamlets and occasionally even in the country itself two or more consumers may be so situated that they can be served economically from one transformer. For such cases the three-wire secondary circuit (220/110 volts) required along the highway is supported in a vertical arrangement on a steel bracket fastened to the side of the pole. The neutral conductor is placed above the others to provide greater safety in the event of a primary wire falling across the secondary circuit. The neutral wire is bare and the other two are provided with a double-braid weather-proof covering. The wires of this circuit are, without exception, medium hard-drawn copper and all joints are soldered. No. 6 B. & S. gage is the minimum size used.

Underground Cable Construction. The increase in cost of labor and material, one of the conditions resulting from the great war, made itself evident in the building of power lines as in other classes of construction. This led the Commission's engineers to investigate the possibilities of underground construction in rural districts. It is unnecessary to state that the use of cables laid underground is a well-established practice, but it may be of interest to note that their use antedated the use of pole lines. The extensive application of underground cables to rural service is, it is believed, quite new, and the methods of installation and the design of material and equipment were given comprehensive study.

At the present time the price quoted for cable is such that the installed cost is higher than for overhead construction. This has to a large extent limited the installation of the underground cable and its use for the present is being confined to lines where unusual difficulties are presented to overhead construction. The Hydro-Electric Power Commission has installed approximately 175 mi. of underground cable lines.

Transformers and Meters. Due to the fact that the average number of consumers per service transformer is small, little advantage is obtained in diversity of the load on the individual transformer. The transformer must be capable of carrying the maximum load which is usually of short duration. On the other hand, the number of transformers connected to one feeder is large, due to the relatively small average transformer and also due to the fact that there is a high diversity in the transformer demands on the feeder. At the time of peak load on the rural feeder there is, therefore, a large number of transformers from which the consumers are drawing little or no current, and these lightly loaded transformers result in a low power factor for the load on the feeder, which is of course undesirable. To ameliorate this condition, particular care has been taken in specifying that tranformers shall have low exciting current. In other respects, the transformers are similar to those used in urban systems. The rated voltage is 2,200/220-110. The minimum size used is of 2 kva. capacity and there is more demand for the 3 kva. than for any other size. The ratings of the watt-hour meters commonly used in measurement of power are 10-ampere, two-wire, 110-volt and 15-ampere, three-wire, 220/110 volts, and for either 25 or 60 cycles.

Where conditions have led to the use of voltages other than those employed in the standard circuit, modifications have, of course, been necessary in the tranformers used.

Progress of Hydro-Electric Power Commission's Rural Construction

Year	Number of rural power districts operating	Number of consumers	Miles of primary lines	Total capital invested
1922	30	1,511	335	$ 801,006
1923	52	4,167	605	1,328,261
1924	82	9,961	909	1,967,548
1925	95	12,395	1,288	2,658,515
1926	107	17,065	1,953	4,005,163

NOTE: The legislation under which the lines are now being constructed was approved in June, 1921. Lines built prior to the 1921 amendment of the Power Commission Act have gradually been absorbed into the new scheme and the data therefor is included in the figures shown in the above table. The mileage thus included is approximately 350.

Power Required by Rural Systems. It will be interesting to note the average amount of power required by rural power districts as supplied to them in 1926 and given below by systems:

Power Supplied to Rural Districts to Serve Farm, Hamlet and Power Uses

System	Township distribution —hp.	Rural power district distribution —hp.	Total hp.
Niagara system	6,148	6,653	12,801
Georgian Bay system—Severn division		94	94
Georgian Bay system—Eugenia division		12	12
Georgian Bay system—Wasdells division		120	120
St. Lawrence system		123	123
Ottawa system		95	95
Central Ontario and Trent system		337	337
Total	6,148	7,434	13,582

Part 3. Operation and Results

A Basis for Estimating Rates. It was not long before the officers of the Hydro-Electric Power Commission found that representations made in the petitions from rural residents were often not a safe basis upon which to estimate. It was decided, therefore, to establish a minimum business basis of a minimum conected load per mile upon which to estimate rates to those requesting information upon proposed electrical rural service.

In many districts it has been found that early efforts made by those interested in securing rural service do not result in a sufficient number of contracts to meet the assumed basis upon which the rates submitted were made, that is, three farm contracts per mile or the equivalent thereof. In such cases it becomes necessary for a representative of the Commission to meet the working rural committees and again deal with the various factors involved, and it usually happens as a result of these further educative efforts and the renewed efforts of those interested, that the necessary amount of business is pledged.

Customers served from rural power lines would, of course, like to obtain their electrical service at the same rates as their friends "in town." Obviously, it is impossible to serve only about three electrical consumers per mile at the same rate at which service could be dispensed to hundreds of consumers per mile. Again, in rural districts there is not the variation in kinds of loads that is found in urban centers, with the result that rates based on service at cost must carry a service charge higher than the service charge for an urban municipality. With the introduction of electrical rural service the attention of rural residents has been directed to a broader outlook on the whole problem of electrical distribution, and the rural citizens are appreciating more fully the basic conditions which govern in electrical distribution under various circumstances. The net result is that the rural consumers have become contented with the results of electrical service to their districts, especially as most rural power districts are showing surpluses and annual adjustments result in decreased cost. The rural consumer is increasing his uses of the service and finding the cost of doing it electrically lower than that of doing similar work by former methods.

With respect to the feature of diversity in rural power districts or the resale of power, it may be stated that this diversity varies greatly and accrues to the advantage of the rural power district. It has been found where industrial plants are located in rural districts, combining with the general rural load, that, under certain conditions, there is effected a complete resale of the power for at least two purposes, and thus a relatively small amount of power purchased is made to serve a fairly large connected load. This diversity factor varies on the "Hydro" rural systems from 3 to 10.

Rural Electrical Service Classification. To enable the Commission to deal with the various rural situations in a fair manner, it is necessary to distinguish between different classes of services. A schedule of classification is furnished to prospective rural electrical users, and in contracting with their township they are required to choose, with certain limitations, from the classes enumerated as follows:

Class 1. Hamlet Service. Hamlet service includes service in hamlets, where four or more consumers are served from one transformer. This class excludes farmers and power users. Service is given under two subclasses as follows:

Class 1B. Service to residences or stores. Use of appliances over 750 watts permanently installed is not permitted under this class.

Class 1C. Service to residences or stores with electric range or permanently installed appliances greater than 750 watts. Combinations of residence and store supplied from one service shall be not less than Class 1C. Special or unusual loads will be treated specially.

Class 2A. House Lighting. Service to all residences that cannot be grouped as in Class 1. This class excludes farmers and power users.

Class 2B. Small Farm Service. Service for lighting of buildings and power for miscellaneous small equipment and power for a single-phase motor not exceeding 2 hp. or an electric range (motor and range not to be used simultaneously) on a small farm of 10 acres or less in vegetable or fruit growing districts, and 50 acres or less in mixed farming districts.

Class 3. Light Farm Service. Service for lighting of farm buildings, power for miscellaneous small equipment, power for single-phase motors not exceeding 3 hp. and electric range. Range and motor are not to be used simultaneously.

Class 4. Medium Farm Service, Single-Phase. Service for lighting of farm buildings and power for miscellaneous small equipment.

Standard Service—Charges Based on Three Farm Contracts per Mile, 25-cycle Service

Class of Service	1-A	1-B	1-C	2-A	2-B	3	4	5	6-A	6-B	7-A	7-B
1921 Without grant-in-aid		$2.15		$2.73		$6.20	$6.71	$8.17		$12.95		$19.13
With grant-in-aid		1.97		2.50		5.07	5.58	7.04		10.91		15.74
1922	$1.47	1.71	$3.04	2.50	$3.95	5.07	5.58	7.04		10.91		15.74
1923—November	1.22	1.50	2.80	2.01	3.46	4.58	5.09	6.56		10.47		14.53
1924—June		1.41	2.55	2.09	3.44	4.55	4.93	5.95	$7.52	9.36	$11.37	13.88
1925—January 12		1.62	2.97	2.03	3.11	4.10	4.28	5.18	6.53	7.47	9.81	11.88
1926		1.62	2.97	2.03	3.11	4.10	4.28	5.18	6.53	7.47	9.81	11.88

NOTE: See footnote to next table. These service charges are one-twelfth of those calculated for the year. In actual practice they are modified to an even five cents.

Estimated Cost of Electrical Service in Rural Power Districts

Class	Description	Demand rating kw.	Demand rating hp.	Average monthly consumption kw.-hr.	Estimated annual consumption charge (net)	Estimated annual service charge (net)*	Total estimated annual cost*
1B	Hamlet service	¾	1	15	$ 8.10	$ 19.44	$ 27.54
1C	Hamlet service	2	2-2/3	150	42.12	35.64	77.76
2A	House lighting	1	1-1/3	15	8.10	24.30	32.40
2B	Small farm service	2	2-2/3	35	17.28	37.26	54.54
3	Light farm service	3	4	40	21.60	49.14	70.74
4	Medium single-phase farm service	5	6-2/3	70	37.80	51.30	89.10
5	Medium three-phase farm service	5	6-2/3	70	37.80	62.10	99.90
6A	Heavy farm service, single-phase	9	12	150	73.22	79.38	152.60
6B	Heavy farm service, three-phase	9	12	150	73.22	89.64	162.86
7A	Special farm service, single-phase	15	20	300	132.84	117.72	250.56
7B	Special farm service, three-phase	15	20	300	132.84	142.56	275.40

*The service charges here shown are the standard service charges for the several classes of service. It should be fully understood that the service is at cost. The above table is designed to represent initial standard conditions and therefore usually represents the maximum rates for any district to which energy could economically be transmitted under the specified condition that there must be at least three farm contracts per mile or their equivalent.

power for single-phase motors up to 5-hp. demand or an electric range. Range and motor are not to be used simultaneously.

Class 5. Medium Farm Service, Three-Phase. Service for lighting of farm buildings and power for miscellaneous small equipment, power for three-phase motors up to 5-hp. demand, or an electric range. Range and motor are not to be used simultaneously.

Class 6. Heavy Farm Service. Service for lighting of farm buildings and power for miscellaneous small equipment, power for motors up to 5-hp. demand and an electric range, or 10-hp. demand without an electric range. Single or three-phase service will be given at the discretion of the Hydro-Electric Power Commission of Ontario.

Class 7. Special Farm Service. Service for lighting of farm buildings, power for miscellaneous small equipment, power for three-phase motors from 10 to 20-hp. demand and electric range. Single or three-phase service will be given at the discretion of the Hydro-Electric Power Commission of Ontario.

Syndicate Outfits. Any consumers with contracts in any of the foregoing farm classes may, with the approval of the Hydro-Electric Power Commission of Ontario, form a syndicate under a separate contract for the purpose of operating jointly a syndicate outfit, provided the summation of their relative class demands is not less than the capacity of the syndicate motor.

The experiences of the Commission in rendering rural electrical service extending over a period of years are embodied in the rates and the classification of services given above, and these have proved satisfactory with respect to all applications for service thus far received.

Rate Structure for Rural Electrical Service. The rates quoted in a rural power district are determined upon the same basis as the Commission determines the rates for city or town service; namely, at cost adjusted annually. The effect of the provincial grant-in-aid towards the capital cost of primary lines and secondary equipment in reducing the fixed charges due to capital invested is taken into proper consideration.

The rates may be said to consist of two parts: (1) The service charge, which is designed to cover the annual fixed charges and the operating cost of the distribution system in the rural power district, and (2) the power charge which is based on the cost of power at the distribution center from which the rural lines originate, and is in the form of a charge per kilowatt-hour for the first 14 hr. use per month of the consumers' class demand rating, and a follow-up kilowatt-hour charge with a maximum of two cents. There is a prompt payment discount of 10 per cent on the total bill.

Changes of conditions and classifications and the effect of the provincial grant-in-aid have resulted in changes of service charge from time to time. The accompanying table gives the standard service charges in use from 1921 to 1926, inclusive.

The accompanying table gives the estimated costs of electrical service in a rural power district of a 25-cycle system with power at 5 cents per kilowatt-hour for the first 14 hr. use per month of the consumer's class demand rating, and 2 cents per kilowatt-hour for all remaining uses, and with a prompt payment discount of 10 per cent. (Prompt payment means that the consumer must pay his bill within 10 days of the time his account is rendered.)

After service is installed in a rural power district various factors determine the rate of growth. Among these factors are the base rate for the power itself, that is, the cost of the power at the point or points where it is supplied to the rural power district; the relative prosperity of the district as a result of favorable or unfavorable crop years; the enterprise and temperament of the individual farmers; the cost and available supply of efficient labor; and the persistence and ability of the salesmen dealing in electrical appliances as used on the farm. The growth of a rural electrical system is frequently stimulated by the resource and energy of some public-spirited individual, who perhaps may be a member of the local council, or who, in other ways, takes a keen interest in the welfare of his district. Moreover, one enterprising and up-to-date farmer in a district favorably situated for obtaining lower cost power will, by his example, frequently encourage a very rapid growth in consumption and use of electric power, and this, in turn, results in lower costs permitting still further consumption. In many rural power districts that have been operating for a few years reductions ranging from 5 to 55 per cent have been made in the standard service charges.

Promising Future for Rural Electrical Service. As previously pointed out, there has been a substantial reduction in the cost of service in rural districts, and this is especially marked where it has been possible to add to the residence and farm loads the power load required for rural industries. Individual electric plants driven by internal-combustion engines have, for years, had a place in many rural districts. In such instances the advantages of electric light to rural residences have served to stimulate the desire for other advantages conferred by a fuller use of electrical energy, and usually when a service is proposed to be installed in a rural district by the Hydro-Electric Power Commission the owners of individual electric plants driven by internal-combustion engines are the first to sign the contracts for new service. The Commission's field men reporting from rural districts have drawn attention to numerous instances where those contemplating an investment in an individual electric plant are delaying such purchase in the hope that service by the Commission may be extended to their township. Viewed, therefore, from certain standpoints, the individual plant, instead of being wholly a competitor, has often proved to be a good forerunner for the introduction of rural electric service by the Commission.

The first rural distribution lines were built by the Commission in 1912 as rural extensions from towns. The building of such extensions was continued in a relatively small way until, in 1917, the cost of material and labor for such work, owing to conditions brought about by the Great War became prohibitive and consequently little progress was made between 1917 and the beginning of 1921. Since 1921 rural electrification has been stimulated by better legislation, by the government grant-in-aid, by the successful working of the installations already in operation, by the cheapening of materials, by improvements in technique and by the growing demand from the rural districts themselves for electrical service.

The extensions being made in the main transmission and distribution lines of the municipal-owned hydroelectric undertaking are constantly opening up new rural territory and present indications are such as to promise for the future an unprecedented extension of rural electrical services. The benefits of such service at cost are now being more fully recognized by rural dwellers as a blessing which is revolutionizing domestic and farm labor to an extent never before attained through any other agency. In the broadest sense it is the power of the people being developed by the people for the service of the people.

EDITOR'S NOTE: The foregoing paper also included several photographs with accompanying notes showing examples of the kind of places to which service is given by the Commission, the installation in each particular case, the consumption for a year, and the net cost for the service received. Space does not permit, however, including all this material.

A Method for Calculating Stresses of Arches

A NEW publication dealing with the design of concrete arches, "Analysis of Concrete Arches," by W. P. Linton and C. D. Geisler, has recently been issued by the Bureau of Public Roads of the U. S. Department of Agriculture. In their treatment of the subject the authors have developed a method which greatly reduces the tedious and complicated processes usually followed in the calculation of arch stresses. The method makes use of a set of standard forms, based on formulas not greatly different from those found in other texts. Many of the entries on the forms are the same for all arches and can be printed on them; and the authors have presented the various steps in filling out the forms in such a way that the work is largely mechanical and the chances of error greatly reduced. A copy may be obtained by addressing the U. S. Department of Agriculture, Office of Information, Washington, D. C.

Agricultural Engineering and Fuel Research*

By O. B. Zimmerman[1]

President, American Society of Agricultural Engineers

NO ONE will gainsay that power farming is playing an important part in the development of agriculture—and that power farming is going forward with strides which are almost disconcerting.

Whole groups of machines which have been suitable for hand or horse operation are being cast aside while the farm equipment manufacturers and others vie with one another in their efforts to bring about more and more suitable equipment of the new types. This development means nothing more than that forced adaptation is taking place to meet the new economic requirements of agriculture. Speed, efficiency, low cost of production, high accomplishment per man-hour, brain in place of brawn, are the bywords. Agriculture has awakened to the problem of industrialization.

In this application of mechanical power and the adjustment thereto, the source of that power is a vital factor both from the standpoint of the fuel utilized and the method of its generation. It would seem, therefore, that we as agricultural engineers must give still more serious thought to this question than we have. We must not court a hazard in the way of inadequate possibilities which may be costly or wasteful to that huge population which we serve.

Viewed en masse, manufactured gas fuel does not appear to lend itself to the light mobile units required by agriculture; electricity has its problems under review and will find its logical place; coal as such has poor prospects except in ordinary use; the liquid fuels have bounded into such prominence that all eyes are fixed thereon.

The press, however, both general and technical, is continually bringing up the question of the persistence in availability of nature's liquid fuels. Much conflicting testimony from the various authorities exists, due perhaps to its speculative nature, over the known sources and known data regarding the invisible pools of oil and the future methods of their reclamation. We can assume, however, that we shall long have available gas, gasoline, kerosene, crude oil, alcohol and coal as well as electricity. Then the question arises shall we continue to develop a high type of engine to utilize each of these fuels, or where shall we lay emphasis? Should we choose wrongly owing to lack of broad vision of other dependent factors, serious consequences would result. Any radical or sudden economic change in either fuel or engine would be likely to render obsolete the most carefully designed machinery dependent thereon. We must have sound designing and stable power resources.

Obviously then our attention and efforts must be carefully directed by the highest type of research, so that we may follow these fundamentals. It has often been proven that any problem which man sets about to solve scientifically, results in a distinct improvement upon nature's normal form. We might perhaps say this in another way: "Let us give nature a fair chance to show what she can do."

For agricultural purposes, especially for the field or mobile units, we do not see at the present time a better all-around source of power than the internal-combustion engine.

The source of fuel for such engines has passed through some remarkable changes. These changes are still going on. Going back thirty years, we recall that we had to deal with the rough fractions of crude oil, gasoline and kerosene, which were being tried as engine fuel and then only with rather indifferent results. Economy and satisfactory operation were relatively unknown. At that time little progress had been made in changing over from those engine types which operated on illuminating gas to what has since resulted. Those engines bore many earmarks of steam engine design.

Twenty years ago kerosene began to be exploited as a successful fuel which, owing to its greater availability in nature's crude oils, was investigated by the engineers as the logical fuel. Gasoline, however, held so many more desirable characteristics that even at the disadvantage of rising prices it was held strongly in the running by automotive engineering. Inasmuch as nature did not provide in the crude this desirable liquid in proportion to engineering requirements, the practice of cracking developed in the refineries. The oil technologist sought this and other means of reapportioning the mass supplies to meet commercial needs. So we see in the fuels, as we saw in the engine design, refinements crowding upon one another to develop higher efficiency and satisfaction.

Up to a short time ago relatively little information was popularly available as to the minute nature of liquid-fuel elements. It may even be safely said today that relatively few internal-combustion-engine designers have more than a vague idea of the nature of liquid fuels. Chemically, liquid fuels have long been known to consist of indiscriminate mixtures of various series of chemical compounds, according to their source.

Just how all of this came about in nature we must leave to the geochemist to explain. Taking what is given us by nature in these earth-bound pools we find the fluid oils, taken all together, to be a conglomeration of complex unstable hydrocarbons which are identifiable and fit into several series of mathematically related groups such as the paraffins, the olefins, the benzines.

Thus far there is little new in this presentation, but let

There is surely no place for alarm on the score of available supplies of liquid fuel so long as carbon and hydrogen are to be had. There need be no serious objection to this outlook on account of the time argument, nor even of cost. The chemists and engineers will readily solve these problems when the economics of the situation demand it

*Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Pittsburgh, Pa., October, 1927.

[1]Experimental engineer, International Harvester Company. Mem. A.S.A.E.

us analyze these groups, list their characteristics, and we find the key to an idea which surely foretells evolution in both engine design and available fuel.

I refer to the isomers. Popularly, isomers may be described as being the different structures of molecules which have one common chemical composition but each of which have their individual characteristics physically and chemically. For example, take hexane—C_6 H_{14}—which is known to have five structures. In the one characteristic of boiling point alone they differ as follows: 69, 64, 62, 58, and 46 deg. C., respectively.

In nature's pools it is but natural to expect that the dominating isomer will be the one which is most stable under the conditions surrounding its formation and storage; hence, that is what we should find available in ordinary fractionation.

Let us for a moment view the demands of the engineers who are trying to develop power units suitable to the available fuels. Their desires are for an ideal fuel which is readily and efficiently convertible into mechanical power, one which is reliable, easily controlled, safe, economical.

Engineers have taken each of the fractioned groups of the past and worked out suitable power transformations. Thus evolved the several types of engines, the hot bulb, the Diesel, the Otto, and the standard automobile engine, with all the modifications to meet special needs.

The call for efficiency in each develops insistence on certain characteristics in the fuels to overcome the peculiar outstanding troubles. The crude oil types have difficulty with tars and lubrication; those maintaining high internal heats develop lubricating, knocking and control troubles.

Millions of hours of careful thought have been given to overcome these difficulties and to develop present-day fuels and engines. Many more will be needed to keep up with advancement.

Let us again view the stage of the refineries. Cracking processes opened the door to the readjustment in quantities of compositions to meet commercial requirements in about 1914. This started the "breaking down methods" by which the more complex molecular oil structures are transformed into simpler ones, thus providing greater quantities of fuel having a larger percentage of the desired characteristics.

Other chemists and physicists set to work on schemes for building up synthetically the desired structures, so that at this time we are, in general, master of the large and basic operation of "constructing what we want." This latter group is now making startling progress.

Passing to the engineers' program again, let us take another view, namely, the efficiency of transformation of the available heat units into useful power. For example, a high-grade automobile engine operating on gasoline containing 20,000 B.t.u.'s will release 25 per cent of those heat units into useful work; a Diesel engine using crude oil 38 per cent, and a properly designed alcohol engine with 12,500 B.t.u.'s available will give 40 per cent transformation. Here then is a very important consideration. It is not the quantity of heat units available but the efficiency of practical transformation, adjusted of course to meet further the maximum horsepower deliverable per dollar of overall expenditure.

Reread the paragraph on isomers, the one on cracking, the one on synthetic fuel, the one on efficient transformation of heat units, and we can reason thus: If we can break down, if we can build up (and we can do these practically), we can in due time decide cooperatively on a reasonable specification of an ideal fuel which will possess the largest number of desirable features, and then make it.

It is more than certain we shall find the ultra-desirable fuel among the isomers, and while our first thought would lead us to say that that would be a foolish extreme to go to; too expensive; too involved, yet we are evolving, improving in that direction. It is my belief we should not drift to this ideal. Research can carry us along far faster and more cheaply toward that end if we see this requirement.

Let me not be misunderstood. It is not claimed that all the fuel will be of one isomer of a given composition. It is believed that the main constituents will be such as will give a far greater efficiency than uniform composition.

You may ask if the agricultural engineer or the farmer is interested in this program. They surely are. If the farmer must depend in the future upon present sources of liquid fuel supplies, now highly organized to distribute fuel to him promptly, well and good. Research, however, may develop quite another angle to the story, and the sooner we visualize the possibilities of the trend the sooner we can reach them in solution. There is surely no place for alarm on the score of available supply of liquid fuel as long as carbon and hydrogen are available.

There need be no serious objection to this outlook on account of the time argument, nor even of cost. The chemists and engineers will beat those items in jig time when the economics of the situation demand it.

This optimism must not at the same time lull us to sleep. The day is not far off when we shall play with these problems as we do today in metallurgy. Who would have predicted the present wonders of the metallurgical art a generation ago and have guessed half of the present successes?

And so, engineers, we see one of a thousand problems. Let us as agricultural engineers not overlook these speculative problems in research. While they may not be entirely in the field of our activities we have many quite as important research problems, whether they be timely or not. Let us turn on the searchlight of science, trail down the paths of possibilities, seek out the clues to advancement in our arts and let the country know that the agricultural engineers have a prominent place in this world's work, that of aiding nature to do her best for mankind.

Ethylene Glycol As An Anti-Freeze Solution

UNITED STATES Bureau of Standards tests of various anti-freeze solutions show ethylene glycol to be superior to any others available for the radiators of internal-combustion engines.

A satisfactory anti-freeze solution must cause no damage to the cooling system through solvent or corrosive action and must circulate freely at all temperatures. Other important considerations in its use are convenience, safety, and economy.

The different types of solutions used are salt, sugar, and alcohol. Of these, all the salt solutions are electrolylic and cause corrosion of one or more of the metals with which they may come in contact. The sugar solutions, on the other hand, if concentrated enough to prevent freezing at low temperatures, are highly viscous and do not circulate freely.

The principal alcohols used in anti-freeze solutions are denatured alcohol, wood alcohol, distilled glycerine, and ethylene glycol. The well-known objections to denatured alcohol are its low boiling point, its injurious effect on the nitro-cellulose finishes now commonly used on automobiles, and its unpleasant odor. Wood alcohol is objectionable for the same and additional reasons. Its fumes may be harmful, and it sometimes contains acids which are injurious to radiators. Distilled glycerine, while superior to alcohol, is considerably more viscous. Mixtures of the above materials have been used with indifferent success.

Ethylene glycol, a chemical compound having the formula CH_2OH, overcomes all of the above objections. Bureau of Standards tests show that it gives more protection for the same concentration than either glycerine or denatured alcohol, it is not corrosive, and only slightly more viscous at low temperatures than denatured alcohol solutions of similar concentration. While it is practically non-volatile at the boiling point of water, the boiling point of its solution in water, up to fifty per cent, is practically the same as that of water. Also its volumetric heat capacity is about the same as that of water, so it does not cause the engine to run hot or cold.

While the first cost of ethlyene glycol is higher than that of alcohol, it can be saved and used year after year. It has the additional advantages of being noninjurious to automobile finishes, non-inflammable, non-poisonous, and practically odorless.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture

Ventilation in Trickling Filters, A. M. Buswell and A. L. Elder (Pub. Works, 58 (1927), No. 4, pp. 154-156, fig. 1).—Studies conducted by the State Water Survey of Illinois are reported which showed that ventilation in trickling filters is not always obtained by the downward flow of air through the filters but can be obtained as well by upward movement. Calculations indicate that air may easily move with such velocity in trickling filters that the loss of oxygen in the air, caused by the biochemical oxygen demand of the sewage in its passage through the trickling filter, is within the observational error of the oxygen determination.

Analyses of the air in filters constructed with an adequate drainage system, but having no special provision for ventilation, failed to show a significant depletion of oxygen.

High Silicon Structural Steel, H. W. Gillett (U. S. Department of Commerce, Bureau of Standards Technology Paper 331 (1926), pp. 121-143, figs. 10).—The results of tests on specimens of Freund steel are presented, showing it to combine the desirable properties of high yield point and high ductility. The steel is unusually high in silicon, containing about 1 per cent, and low in carbon, containing less than 0.15 per cent. Published data on the alloying effect of silicon and of manganese are summarized and specifications for the high silicon steel are presented.

Distribution of Cellulose in Imhoff Tanks, H. Heukelekian (Public Works, 58 (1927), No. 4, pp. 133-135, fig. 1).—Studies conducted at the New Jersey Experiment Stations are reported which showed that fresh sewage solids collected from the inlet end of an Imhoff tank have a relatively high cellulose content. The cellulose content is not only higher due to higher solids concentration, but it forms a higher percentage of the solids themselves. A long flow chamber therefore affects solids concentration and the chemical composition of the solids, due to the difference in settleability of the different components. It was found that in a tank which is shallow and long there will be an uneven quantitative and qualitative distribution of solids, while if the tank is built for the same capacity but deep the distribution of solids will be more uniform.

Household Refrigeration, H. B. Hull (Chicago: Nickerson & Collins Co., 1926, 2. ed., enl., pp. 389, figs. 135).—This is the second edition of this book, dealing with the principles, types, construction, and operation of both ice and mechanically cooled domestic refrigerators and the use of ice and refrigeration in the home. It contains chapters on refrigeration units and theory, ice for refrigeration purposes, refrigerants, heat transfer, refrigerating systems, household refrigerating machines (compression and absorption types), household refrigerators, operation of ice refrigerators, testing of ice refrigerators, preservation of foods in the home, and miscellaneous tables.

Alcohol Motor Fuels Consisting of Acetylene Dissolved in Alcohol or in Acetone-Alcohol, M. Rindl (South African Journal of Science, 23 (1926), pp. 268-272, fig. 1).—Studies conducted at Grey University College, Bloemfontein, are reported, from which the conclusion is drawn that an alcohol-acetone-acetylene motor fuel or any fuel containing dissolved acetylene is not likely to be a commercial success, since it deteriorates rapidly and its calorific value is practically the same as that of the solvent. There is also more danger of explosions and fires than in the case of gasoline.

Progress in Sub-grade Soil Investigations, F. H. Eno (Roads and Streets, 67 (1927), No. 2, pp. 82-88).—In a contribution from the Ohio State University a resume is given of results obtained by different agencies in subgrade soil studies.

The Use of Models in the Solution of Indeterminate Structures, G. E. Beggs (Journal Franklin Institute, 203 (1927), No. 3, pp. 375-386, figs. 8).—In a contribution from Princeton University the methods and apparatus used in the study of indeterminate structures are described and illustrated. The use of similar methods and apparatus in the solution of indeterminate barn roof trusses seems possible.

Agricultural Engineering Studies at the California Station (California Station Report 1926, pp. 34-37).—A. H. Hoffman reports that air cleaners of the radiator fan type have been found to be low in efficiency as a class, and in addition have the serious handicap of having to be of necessity where the dust concentration is high.

Studies by E. J. Stirniman of equipment for handling grain in bulk and in sack, which included thirty-seven combine harvesters harvesting 44,892 acres of wheat and barley, showed that the rate of harvesting per foot of width was the greatest for the largest combines. Combine labor cost per acre for sacked grain was $1.57 and for bulked grain, 58 cents.

Experiments by Stiriman on equipment and methods for removing stumps showed that the cost of clearing land of 6 to 18-in. oak stumps with the barrel type stove was considerably lower than by the pulling process. Green or wet stumps opened with a light powder blast in the winter or spring burned readily the following fall. Dry softwood stumps burned to a depth of from 4 to 8 ft. below the ground level. Green or wet stumps did not burn below tillage depth.

A study of walnut dehydrators showed that the thermal efficiencies of gas heated plants varied from 11.9 per cent to 34.3 per cent, of oil heated plants from 9.8 to 34 per cent, and of electric heated plants from 28.1 to 56.8 per cent. The cost, including operation, interest, and depreciation for electrically heated plants, were favorably comparable wtih those for the other plants.

Some Factors Affecting the Irrigation Requirements of Deciduous Orchards, F. J. Veihmeyer (Hilgardia [California Sta.], 2 (1927), No. 6, pp. 125-284, pls. 3, fig. 44).—This is a contribution resulting from cooperative investigations made by the station, the U.S.D.A. Bureau of Public Roads, and the California State Department of Public Works. The purpose is to present certain data relating to soil moisture conditions prevalent in commercial orchards, and to analyze the causes resulting in losses of moisture from irrigated soils. The experiments included (1) observations of moisture conditions in commercial orchards in the Santa Clara Valley, (2) observations of orchards at the station, (3) studies of the behavior of young prune trees in tanks under controlled conditions, and (4) a comparison of moisture losses by evaporation and transpiration from soils and studies of moisture losses from the soil in tanks and from field plats.

The soil moisture records presented indicate that the use of water by mature prune trees does not seem to be influenced by the amount of water present in the soil, provided the soil moisture content has not been reduced below the wilting coefficient. The intensity of atmospheric evaporating power and leaf area seemed to determine the use of water by the trees. The amount of available water present in the soil and the state of growth of the trees, except in so far as this affected leaf area, seemed to be of secondary importance. The yields, drying ratios, size, and quality of prunes produced did not seem to be related to the frequency or amounts of water applied to the soil. Mature prune and peach trees did not seem to be affected by changes in soil moisture content unless the moisture content of the upper 6 feet of soil was reduced to about the wilting coefficient. The results obtained in studies of Muir peaches were in general the same as those obtained with mature prune trees.

Studies of young prune trees grown in tanks under controlled conditions indicated that the use of water by these young trees was not influenced by the amount of water in the soil above the wilting coefficient. Under comparable atmospheric conditions the rate of extraction of moisture by the roots of the trees was the same whether the moisture content of the soil above the wilting coefficient was high or low. Within the range of experimental conditions used, atmospheric conditions had little influence upon the amount of residual moisture in loam soils at the beginning of permanent wilting. Usually about one-half of the soil moisture between the wilting coefficient and the hygroscopic coefficient was taken by the trees. It is thought probable that although the wilting coefficient is not the lower limit of available moisture, it is a better basis for comparing moisture properties of soils than is the hygroscopic coefficient.

A comparison of the evaporation losses from the surfaces of bare soils with the amount of water taken from the soil by plants showed that evaporation losses were extremely small portions of the total amounts of water lost from the soil. The direct evaporation losses were confined mainly to shallow depths of soil. Moisture below the upper 8 in. was lost at an extremely slow rate. The losses of moisture from the surfaces of soils exposed to evaporation for much longer periods of time than are usual between irrigations were insufficient to prohibit the growth to maturity of barley and vetch plants.

Cultivation did not influence the losses of moisture by evaporation from the bare surfaces of the soils in the tanks and in field plats, and did not materially influence the distribution of moisture in these soils. The loss of moisture by evaporation from the surfaces of soils immediately following the application of water was found to be a large portion of the total evaporation losses for a long period of time. About half of the loss in eighty days occurred during the first week after irrigation, and the greater amount of this was lost before the soil was in condition to be properly cultivated.

After the water applied to the soil had become distributed, the movement of moisture by capillarity was found to be extremely slow. The movement of moisture from moist soils to dry soils packed in columns and remaining in contact with each other for 4.5 months was slight in amount and extent in both an upward and downward direction. The results indicate that the capillary movement of moisture from moist soil to drier soil, when the soil is not in contact with a free water surface, is too limited in extent and probably in rate to be effective for use by plants.

Agricultural Engineering Studies at the Indiana Station (Indiana Station Report 1926, pp. 17-20, fig. 2).—Soil erosion studies have shown that a grade of 0.6 ft. per 100 ft. is a maximum for Paoli soil. Improvement of moisture content with greater seepage of water into the hillsides promises to be an important secondary result of terracing.

Temperature tests of poultry houses showed that in unheated houses the average winter temperatures remain from 1 to 3 deg. F. above the outside temperature, with a lag of about an hour. However, when the outside temperature dropped to zero or lower, the inside temperature averaged from 3 to 15 deg. higher. The use of brooder stoves reduced the variation in inside temperature approximately 10 deg., and in extremely cold weather maintained a temperature 20 deg. higher than the outside temperature. The relative humidity varied rather uniformly in inverse ratio to the temperature. When the curtains were down in partially open front houses, the air changed once a minute or oftener depending on the wind. Atmospheric conditions outside the house caused the ventilators to function with great irregularity, sometimes reversing the direction of air movement, and thus demonstrating the ineffectiveness of poultry house ventilators as commonly designed for partially open front houses.

In an experiment on dairy feed grinding, in which definite grades of fineness were established for grain crushed or cracked, medium ground, and pulverized, both the power and labor requirements were more than seven times as great for pulverized corn sufficiently fine for all of it to pass through a No. 14 screen than for cracking it so that a No. 4 screen was required.

In studies of the artificial cooling of apple storages, it was found that the cost, including ice and electric fan operation for 1,200 bu. of apples, was 24.4 cents per bushel for a period of two months. The temperature ranged from 12 to 15 deg. F. higher in the uniced room during the warm period but was not appreciably higher thereafter, and even ran lower during the last two weeks on account of lack of ventilation in the iced room during the prevailing cold nights. Grimes and Jonathan apples kept in the iced room remained in salable condition about one month longer than similar fruit kept in the uniced room.

Data are also briefly reported on the generation of electricity by windmills, on tests of an experimental rotary soil tiller, and on rural electrification.

Nebraska Tractor Tests, 1920-1926, Rules for Official Tractor Testing, and the Nebraska Tractor Law (Nebraska Station Bulletin 220 (1927), pp. 38).—This bulletin summarizes all of the reports of the Nebraska official tractor tests conducted since this work began in 1920 under the provisions of the Nebraska tractor law. During the seven years that this work has been in effect tests have been conducted on 130 different models and types of tractors. During the first four seasons of testing there were several tractors the claims of which had to be revised before they could complete the test. During the last three years, however, every tractor tested was able to go through the test and to meet all the original claims made for it.

A general improvement in operation and design was noted in all the later tractors. Practically all now employ air cleaners and inclosed gears as a protection against the effects of dust, and also give evidence of considerable attention to simplification of design and to improved ease of operation and servicing.

Agricultural Engineering Studies at the Idaho Station (Idaho Station Bulletin 149 (1927), pp. 16, 17).—Preliminary studies of the rate of infiltration of water into soils indicated a very definite relation between the depth of water absorbed and the time during which the water stands on the soil surface. This relation appears to be expressed by the formula $D = cT^n$, in which D equals the depth of water infiltrated in feet, T equals the time of infiltration in hours, c equals a coefficient varying from 0.038 to 1.7, and n equals an exponential factor varying from 0.2 to 0.87. Variations in the rate of infiltration from 0.038 ft. per hour to 0.23 ft. per hour occurred within a distance of less than 100 ft. on the alkali soils of the tract used in the project on reclamation after drainage. Tests on the Palouse silt loam indicated a rate of 1.7 ft. per hour.

Studies of the effect of various treatments on the leaching out of alkali salts from drained land indicated that planting with sweet clover and repeated leaching will serve to reclaim land that is not extremely impervious and that has satisfactory underdrainage. Infiltration trials showed that the rate at which the good and bad spots in the soil took up irrigation water varied greatly. It is evident from these results that the rate of leaching in soils of individual plats will be far from uniform.

A survey of the use of electricity on Idaho farms showed that about seven thousand out of the total of forty thousand farms in the state are supplied with central station electric service. These farms are very largely concentrated in the irrigated sections of the state where the extensive use of electric energy for irrigation pumping has made possible the wide distribution of electric service. Decidedly more energy is used per month on farms served by the commercial power company than on those served by the mutual companies on the Minidoka project. This is true in spite of the fact that the monthly bills are lower under the mutual company.

Annual Report of the Agricultural Engineer to Government, Bombay, Poona, for the Year 1925-26, W. M. Schutte (Bombay Department of Agriculture, Annual Report 1925-26, pp. 196-201).—Investigational work is reported on the modification of agricultural implements, including plows, seed drills, and winnowers, and work on the development of pumping plants.

Cost of Using Horses, Tractors, and Combines on Wheat Farms in Sherman County, Oregon, R. S. Washburn and H. D. Scudder (U. S. Department of Agriculture Bulletin 1447 (1926), pp. 44, figs. 12).—The purpose of this study is to show the probable costs of using combines, horses, and tractors, and to present the important points to be considered in the selection of combines and motive power. The bulletin is based on data obtained in the study noted above. The kinds, amounts, costs, economy, efficiency, seasonal distribution, advantages and disadvantages, etc., of horse and tractor work, and the types of, and the cost and the advantages and disadvantages of using combines are discussed. Comparative costs are given for harvesting and threshing with horse and tractor-drawn combines; for harvesting and marketing bulked and sacked wheat cut with tractor-drawn combines; and for harvesting, threshing, and marketing wheat where combines and where headers and stationary threshers were used.

Progress Report on Cost of Production Route in Choctaw County, Mississippi, 1925, L. E. Long and H. W. Reynolds (Mississippi Station Bulletin 237 (1926), pp. 23).—A report for the calendar year 1925 of a study, based on records from 19 farms obtained in cooperation with the U.S.D.A. Bureau of Agricultural Economics.

The weighted average of total value of products per farm was $1,747.72, of farm income $842.98, and of value of operator's labor $312.86. The return on investment (farm income minus value of operator's labor) varied from —2.1 per cent to 28.2 per cent, averaging 12.2 per cent. The cost of producing the chief crops, butterfat, poultry products, and pork, varied as follows: Cotton from 3.5 to 16.3 cents, averaging 10.2 cents per pound; corn 32 cents to $1.52, averaging 75 cents per bushel; oats 19 cents to $1.09, averaging 41 cents per bushel; lespedeza hay $1.61 to $48.47, averaging $4.61 per ton; butterfat 16 to 88 cents, averaging 41 cents per pound; eggs 10.7 to 64.9 cents, averaging 19.7 cents per dozen; chickens (meat) 14 cents to $1.51, averaging 61 cents; and dressed pork $2.95 to $25.33, averaging $10.65 per hundred pounds.

From 44.4 to 230.4 hours of man labor, averaging 104.5 hours, and from 22.1 to 91.9 hours, averaging 37 hours, of horse labor were used per acre of cotton; and 21.4 to 153.4 hours, averaging 41.6 hours of man labor, and 14.9 to 163 hours, averaging 33.8 hours, of horse labor per acre of corn. The cost per animal unit of maintaining work stock varied from 9.2 to 25.1 cents, averaging 13.9 cents per hour of work.

Cost of Producing Winter Wheat and Incomes from Wheat Farming in Sherman County, Oregon, R. S. Washburn and H. D. Scudder (U. S. Department of Agriculture Bulletin 1446 (1927), pp. 40, figs. 12).—This bulletin is based on data on the cost of the factors of production and farm earnings obtained by personal interviews, 450 records being obtained, divided nearly equally among the years 1920, 1921, and 1922. The area studied is dry-farmed, approximately 36 per cent of the average acreage per farm in 1922 being in winter wheat, 39 in summer-fallow, 4 in other crops, 19 in pasture, and 2 per cent in waste land. So far as possible the data were reported in terms of physical requirements. The quantity requirements of labor and materials were analyzed, and the effect of differences in methods and practices on costs and returns were measured.

Tenure; distribution of livestock, farm area and capitalization; receipts, expenses, and earnings; quantity and value of products used on the farm; the cost and utilization of man labor, horse work, farm machinery, and their relation to the size of farm; costs by tenure; cash and noncash costs of production; variation in cost per bushel; and the relation of yields to costs are discussed.

Itemized estimates are included on the cost of production for 1923 and 1924, and suggested plans for the organization and management are given for a 640-acre farm, a 1,280-acre farm operated with horses, and a 1,280-acre farm operated with tractors.

Milk Clarifiers and Milk Filters, T. M. Olson (South Dakota Station Report 1926, pp. 16, 17).—Numerous tests with a clarifier and filter indicated that there is very little, if any, difference in the keeping quality of milk that has been clarified and pasteurized, and milk that has been pasteurized and filtered. Acidity tests likewise showed little difference. The time of pasteurization exerted a much more noticeable effect. Bacterial counts, methylene blue reductase tests, and Cooledge hydrogen-ion determinations substantiated these results. The clarifier, however, reduced the cell counts by more than 50 per cent, while the filter exerted no appreciable effect on the number of cellular elements in the milk.

Sediment tests were in favor of the clarified samples. Cream line, however, seemed least affected by the filter, as clarification at 80 deg. F. caused a slight decrease in the cream line. The time required in assembling, dismounting, washing, and sterilizing the filter was considerably less than the time required for the same operation with the clarifier.

Investigation of Current Relations in Agitator Flash Pasteurizers and Their Influence on the Death of Organisms, K. Richter and H. M. Wendt (Milchwirtschaft Forschungen, 3 (1926), No. 2-3, pp. 200-208, figs. 6).—The amount of direct flow through two types of flash pasteurizers was determined by first sending skim milk and then whole milk through the pasteurizers. The length of time that different portions remained in the container was estimated from the fat content of the milk coming out.

The results showed that in one type of pasteurizer, which was cylindrical in shape, portions of the milk passed through in a few seconds, while other portions remained for as long as 4 min. The top of the other type of pasteurizer was larger in diameter than the bottom. The maximum and minimum time required for milk to go through this type was 70 and 15 sec., respectively. In the latter type the destruction of Bacillus coli was very complete.

Cost of Producing Crops in North Dakota, R. E. Willard (North Dakota Station Bulletin 199 (1926), pp. 32, fig. 1).—The various items of costs, costs per acre, and costs per unit of yield for wheat, flax, rye, oats, barley, potatoes, millet, alfalfa, sweet clover, and corn for grain, fodder, silage, and hogging down are presented for the state as a whole and for the four geographical sections—the Red River Valley, central, northwestern, and southwestern divisions. The greater part of the records covered the years 1921 to 1923, inclusive. Those for wheat for the state covered 1919 to 1925, and those for flax and rye, 1921 to 1925. The method of calculating costs is the same as that used in Bulletin 165. The cost per acre of producing crops decreased about 60 per cent from 1920 to 1925, due to lowering of the price levels of commodities used by farmers, land rent, value of farmers' labor, and increased efficiency of the farmers.

Cost of Filling Silos, P. E. McNall and W. A. Hartman (Wisconsin Station Bulletin 386 (1926), pp. 12).—Data from 282 farms in 1921 to 1923, inclusive, show the cost of filling silos averaged $2.06 per ton, varying from $2.39 for silos of 50 to 70-ton capacity to $1.89 for those having a capacity of over 111 tons. The difference in cost consisted of 5 cents for man labor, 3 cents for horse labor, 11 cents for use of silo, 22 cents for use of equipment, and 9 cents for interest. The cost per ton for engine and cutter varied from 37 cents for the smaller silos to 33 cents for the larger silos when the engine and cutter were hired, and from 43 to 24 cents when owned, indicating that hiring was cheaper for silos of less than 100 tons capacity.

The Treatment of Milk by an Electrical Method, S. C. Prescott (American Journal of Public Health, 17 (1927), No. 3, pp. 221-223).—Milk from the receiving tank is forced through a regenerative cooler where it is warmed to about 118 deg. F. by exchange with hot milk on the outside. It then passes through a cloth filter to remove dirt and foreign matter and reaches the treating chamber, where it is subjected to an alternating current of 220 volts, 60 cycles. The temperature rises to between 158 and 160 deg. From the heating chamber the hot milk passes to the regenerative cooler where its temperature is lowered by exchange with cold raw milk, and then passes over brine pipes where the temperature is further reduced to about 40 deg.

The taste and appearance of the milk were apparently not affected by the treatment, and the keeping qualities were excellent. A study of the reduction of the number of bacteria showed that during the winter months the raw milk gave a count of less than 200,000 bacteria, and a reduction percentage of approximately 90 per cent was observed. In the warmer months the bacterial count ran from 500,000 to 600,000 bacteria, and the reduction percentage varied from 97 to 98.5 per cent. Of the 20,000 thermophilic organisms in raw milk, 80 per cent were destroyed by this treatment. No colon or tubercle bacilli survived the treatment.

Cleaning Milking Machines, L. H. Burgwald (Journal of Agricultural Research [U. S.], 31 (1925), No. 2, pp. 191-195).—A comparison of three different methods of cleaning milking machines was conducted by the U.S.D.A. Bureau of Dairying. Three single units were first rinsed and washed with hot water and a cleansing solution. For further cleaning, one unit was placed in a 5-gal. crock containing a chloride of lime solution for 24 hr., and another unit was similarly treated with a saturated brine and calcium chloride solution, while the third unit was held in hot water at 160 to 165 deg. F. for from 20 to 30 min. just before milking. The bacterial content of the milk drawn in once a day and twice a day milkings with the machines cleaned in the different ways was compared.

The counts of the milk drawn by the machines held in the hot water for from 20 to 30 min. were uniformly low both in summer and in winter, the average for 342 samples being 2,380 per cubic centimeter. The chloride of lime with or without the brine produced similar results, but the counts were higher than those from sterilization with hot water, especially in the warm weather. There was practically no difference in the results for once and twice a day milkings. Bacterial counts of the sterilizing solutions in the long milk tubes during cold weather did not indicate any correlation with the period over which the solution had been used or the bacterial content of the milk, but in summer there was a direct relation between the age of the solution and the bacterial content of the milk.

The results indicated that making up new sterilizing solutions of chloride of lime or salt and chloride of lime once weekly during cold weather was sufficient, but that during the warm weather fresh chloride of lime solution should be made up daily and new salt and chloride of lime solution should be made up on alternate days.

Some Variations of the Heat Method for Sterilizing Milking Machines, L. H. Burgwald (Journal Agricultural Research [U. S.], 34 (1927), No. 1, pp. 27-33).—In order to prolong the life of the rubber parts of milking machines and at the same time get good results bacteriologically, the work was continued. Three single units were used in this test. Immediately after milking each unit was rinsed by drawing clean, cold water through by vacuum, washed with a brush in hot water (110 to 120 deg. F.) containing washing powder, and rinsed in clean, hot water. The buckets and heads were treated in the same manner and rinsed again in hot water before using.

All the units were placed in hot water (163 deg.) for about 30 min. At this time one unit was removed and placed in a refrigerator and another in a weak solution of chlorinated lime. The other unit remained in the hot water between milkings. In another test with three units, one was sterilized in hot water (148 deg.) and allowed to remain therein between milkings. The other two were sterilized in water (162 deg.). At the end of about 33 min. one unit was removed, hung in a warm room with an average temperature of 75.5 deg., and protected from dust and contamination. The other unit remained in the water between milkings. The bacterial count of milk drawn in the machines sterilized in different manners was compared.

The experiments indicate that sterilizing units at from 160 to 167 deg. for about 30 min. and placing in weak chlorine solution or hanging in a refrigerator will give excellent bacterial results, and that the life of the rubber parts will be materially longer than when units are allowed to remain in hot water between milkings. Hanging in a clean, warm place did not give as low bacterial counts as the other methods. Sterilizing at temperatures of from 145 to 150 deg. increased the life of the rubber parts but did not give nearly as low bacterial counts.

The Purification of Skim Milk Solutions on a Lath Filter, M. Levine, G. W. Burke, and C. S. Linton (Iowa Engineering Experiment Station Bulletin 81 (1926), pp. 30, figs. 5).—Studies are reported which showed that a plant for the purification of creamery wastes must be capable of rapidly destroying milk sugar without developing detrimental acidities. Anaerobic methods such as septic or Imhoff tanks are not suitable, whereas aerobic devices such as trickling filters provide the conditions necessary for the rapid oxidation of milk sugar and organic acids.

In experiments with a small lath filter, consisting of 6 tiers of laths, 2 ft. square and 1 ft. deep, with 4-in. spaces between the tiers, various dilutions of skim milk were applied at rates of 1,125,000 and 2,250,000 gal. per acre per day. The removal of solids at the higher rate was 37.1, 51.1, and 56.3 per cent for 0.5, 1, and 1.5 per cent skim milk solutions, respectively. At the lower filtration rate 46.6 and 51.6 per cent of the solids were eliminated from 1 and 1.5 per cent skim milk solutions, respectively. The elimination of solids took place primarily in the upper 3 ft. of filtration. Suspended solids were developed in the second to fourth foot of the filter.

The oxygen-consumed values for the raw wastes were 195, 375, and 716 parts per million for the 0.5, 1, and 1.5 per cent wastes, respectively. The reduction in oxygen-consuming constituents effected was from 75.1 to 87.3 per cent, being generally well over 80 per cent with all of the wastes used. The elimination of oxygen-consuming constituents took place almost entirely in the upper 3 ft. of the filter. At the higher rate of filtration there was a reduction of 76.9, 74.8, and 71.1 per cent of organic nitrogen from the three concentrations of skim milk wastes, respectively, whereas at the lower rate of treatment there was a decrease of 80.5 and 72 per cent organic nitrogen from the 1 and 1.5 per cent solutions, respectively. The effect of increasing the concentration on the rate of application of the waste was to increase the depth of the filter which functioned in the removal and digestion of nitrogenous constituents.

Ammonification was most marked in the upper layers of the filter. With the 0.5 per cent waste applied at the higher rate and with the two other concentrations applied at the lower rate, the ammonia rose to a maximum in the second foot, decreasing rapidly in subsequent depths. Increasing the concentration or the rate of application to the filter for a given concentration of waste resulted in the elimination of the distinct maximum ammonia content.

There was no evidence of nitrate formation in the first foot. With the lower rate employing 1 and 1.5 per cent skim milk solutions and also with the 0.5 per cent solutions at the higher rate, the nitrites rose quickly to a maximum in the third to fifth foot and then decreased. Nitrite formation was markedly retarded by increasing the concentration or rate of filtration. In all instances a distinct reduction in nitrates was observed in the first foot of the filter. Denitrification was most marked with the higher concentrations, and with the higher rate of application the decrease in nitrates was evident down to a depth of 3 ft. After this initial drop the nitrate content rose rapidly as the wastes percolated through the succesive depths of the filter. The effect of variations in the rate of filtration on nitrate production was particularly marked.

The stability of the effluents was found to be intimately associated with the nitrate content. High nitrates were accompanied by high stabilities. Applying the waste at the lower rate gave stable effluents with the 1 per cent solution, but not with the 1.5 per cent solution. The effluents were considerably more alkaline than the applied wastes. Anaerobic storage of raw wastes resulted in distinctly acid reactions.

Hydroelectric Handbook, W. P. Creager and J. D. Justin (New York: John Wiley & Sons; London: Chapman & Hall, 1927, pp. XXIV + 897, pls. 7, figs. 488).—The purpose of this handbook is to present a compendium of all phases of modern hydroelectric practice. It contains chapters on rainfall; evaporation; factors affecting run-off; estimating stream flow; flood flows; capacity of the development; output capacity and flow demand; storage and power available; hydraulics; general design; timber dams; masonry dams; earth dams; rock-fill dams; headwater control and accessories for dams; conduit intakes; conduits; canals; flumes; steel pipe; wood-stave pipe; concrete pipes; tunnels; water hammer; surge tanks; power house substructure; power house superstructure; hydraulic turbines; electrical design; generators, exciters, and transformers; switching equipment, station wiring, and auxiliary power and lighting; transmission lines; investigations and reports; river gauging; and operation of hydroelectric properties.

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

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RAYMOND OLNEY, Editor

More Power Per Man

WE HAVE come to a realization that human labor is the most expensive power in the world. Throughout the history of civilization the introduction of devices to reduce man labor has always resulted in improved standards of living, more luxuries, and a better civilization. There would be no automobiles, radios, bathtubs, or colleges today were it not for the fact that men have been released from the burden of producing their own food and clothing. Also there would be no one to purchase these products unless, by the use of improved methods, the individual could earn enough to buy them.

The average size farm in India is 3 acres, and the standards of living are low. It is a matter of record that rice, grown in America, with power, machinery and high-priced labor can be exported to Japan at a profit and sold for less than Japanese rice produced with labor at a wage of but a few cents a day. But we need not go to India, or Japan, to illustrate the point. When the year's labor of a man and his family is spent in producing 15 acres of cotton, at prevailing costs and prices, with a few acres in other crops, he does not acquire enough in a year to purchase any of the luxuries of life. If he is able to buy the plainest food, and essential clothing, and does not go further in debt, he is fortunate.

Contrast this condition, with that which has been accomplished. Under improved methods of cultivation he may produce a bale of cotton to the acre. With power and machinery he may handle 25, 40, or even 100 acres of cotton per man, except for the harvest.

It is true there are economic problems involved. It may be we have too many farmers. Certainly there are too many men producing at a loss, and farming marginal lands. Some authorities believe that 10 or 12 per cent of the population on the land, instead of 24 per cent, could produce enough for all.

How does the South stand in the use of power and machinery for increased effectiveness per man? Cotton is the most important crop, commercially, that the world produces. Texas and Oklahoma have shown that under certain conditions cotton can be produced profitably, so the grower reaps the benefit of the crop. More and more it is being recognized that the selling price cannot be changed materially, involving as it does so many factors and so many individuals. There is a definite proof that the cost of production can be controlled.

A planter in Arkansas last year produced, on one farm, cotton at 27 cents a pound under ordinary methods, and lost money. On another farm, under carefully regulated methods and modern equipment, he produced cotton at less than 10 cents a pound. "Why," he asks, "should I follow the old method any longer when I can sell cotton at 10 cents a pound and make a profit, by paying attention to these factors?"

There appears to be a striking parallel between the efforts for more cotton on fewer acres, and our vision of more power and larger units per man. If greater yields of cotton per acre will release acres for food and foodstuffs we now import, is it not also true that greater production per man will release men for the production of things that we now import, or far too often, go without?

DEANE G. CARTER

Are Farm Buildings an Expense or an Investment?

ATTENTION has lately been directed to what has appeared to be the abnormally high cost of farm buildings in relation to other cost factors of agricultural production. More particularly has this been noticed in dairy barns for which it was estimated that the overhead charge equaled 25 per cent of the total cost of market milk and butter production.

A detailed study of all the elements involved in this business, available through survey reports from various parts of the country and covering a wide range of conditions, discloses that the above figure is true only in the case of cows producing below 4,000 lb. of milk annually. High producers, on the other hand, while they require more feed and labor to enable them to produce their maximum, return good profits over and above all cost elements; and in this case the building item is only from 10 to 15 per cent of the total.

Such a study shows further that low producers will not return a profit, even if no building charge is made against them. Obviously the remedy should be to weed out the low producers and house the good cows in a building which will be conducive in all respects to economical and efficient production.

J. L. STRAHAN

A Tribute

"THE crystal ball of most prophets reflects the past and not the future—and post mortems are of increasingly little use to either industry or agriculture. Less and less does business consult the sad curves of forgotten years in planning for the future; more and more does it chart its course against the sure background of accurate cost accounts and known demand. And less and less does agriculture follow the old cycles of production as modern methods and machines speed operations, cut costs and transform loss into profit. The agricultural engineers make no claim to be prophets, but they more than any others are seeing clearly into a future when farming will forget its troubles in prosperity—and each year they are bringing forth practical means of making that prosperity sure."

Thus does "The Country Gentleman" editorially recognize the contribution agricultural engineers are making to the improvement of the agricultural situation. Incidentally, that publication has been unstinting in promoting the agricultural-engineering idea—because its editors believe in it thoroughly.

National Farm Equipment Week

THE dates of February 13 to 18, 1928, were selected as the dates for the third annual National Farm Equipment Week by the sales and advertising departments of the National Association of Farm Equipment Manufacturers at a recent meeting of that Association.

This week is observed annually for the purpose of emphasizing the importance of the use, care and operation of modern labor-saving, cost-reducing farm equipment.

A. S. A. E. and Related Activities

Engineering Analysis of Agriculture Considered at A.E.C. Meeting

A PROGRESS report on the matter of making an engineering analysis of the agricultural industry was presented by L. W. Wallace, executive secretary of American Engineering Council, before a meeting of the admistrative board of that organization at York, Pennsylvania, October 20. The report emphasized the advisability of such an analysis and indicated approximately what it might be expected to cost. As this was a preliminary report, however, no action was taken.

Important action was taken by the board in approving the Wyant Public Works Bill in a revised form. The movement for the reorganization of the federal government to place all its public works functions under the jurisdiction of one department is half a century old and has gained strength materially since 1919. It is widely supported by engineering, manufacturing, and business interests. The present Secretary of Commerce, Herbert Hoover, has long been a prominent leader in the promotion of this cause.

Organized activity along this line within the engineering profession is now carried on by the American Engineering Council's Committee on Government Re-organization of which Gardner S. Williams of Ann Arbor, Michigan, is chairman.

The Wyant Bill calls for the establishment of a major division of public works under the Department of the Interior, and the inclusion in its jurisdiction of rivers and harbors. In the present form of the bill, agricultural engineering activities of the government are left with the Department of Agriculture rather than including it in the new division of public works.

A progress report of the Committee on Street Signs, Signals, and Markings was given by W. C. Powell, chairman. The board voted that action be taken to secure the adoption of the final recommendations of this committee as American Standards. Other important action was also taken in regard to the National Board for Jurisdictional Awards, the Mississippi River problem, the National Hydraulic Laboratory, and the annual meeting of the Council. The dates set for the Council meeting are January 9, 10 and 11, 1928.

An event of the meeting was a banquet attended by members and guests of the Board and of the York Engineering Society. Charles Sioberg was toastmaster and introduced the speakers Dr. Charles H. Ehrenfeld, the Hon. Franklin Menges, L. W. Wallace, Dean Dexter S. Kimbal, and Mayor E. S. Hugentugler in the order named.

F. A. Wirt represented the American Society of Agricultural Engineers at the meeting of the Board.

Pacific Coast Section Meets in January

THE next meeting of the Pacific Coast Section of the American Society of Agricultural Engineers will be held in Los Angeles on or about January 13. Members of the executive committee of the Section will meet in that city November 29 to decide definitely on the date and to arrange for the program.

Further details of the meeting will appear in The Secretary's Letter some time in December, or may be secured from S. H. Beckett, secretary of the Section, University Farm, Davis, Calif.

A Correction

UNDER the heading "Personals of A.S.A.E. Members," it was announced in the November issue of AGRICULTURAL ENGINEERING that Truman E. Hienton was to become associated with the division of agricultural engineering of the U.S.D.A. Bureau of Public Roads as associate agricultural engineer. Mr. Hienton, however, will continue as project Relation of Electricity to Agriculture and as assistant in agricultural engineering at the Purdue University Agricultural Experiment Station.

New A.S.A.E. Members

Jose J. d'Andrade, agricultural engineer, Calharizde Bemfica, 187, Lisbon, Portugal.

George L. Bennett, Sheet Steel Trade Extension Committee, Pittsburgh, Pa.

Barry Dibble, consulting engineer, 20 East Palm Ave., Redlands, Cal.

Deeptimary Haldar, assistant agricultural engineer, Allahabad Agricultural Institute, Naini, E.I.R., U.P., India.

Rhuel G. Harvey, rural service and promotion, Adirondack Power and Light Corp., Schenectady, N. Y.

Robert C. Hienton, rural electrification work, Cleveland Electric Illuminating Co., Cleveland, Ohio.

Burton A. Jennings, assistant extension professor of rural engineering, New York State College of Agriculture, Ithaca, N. Y.

William C. Lord, superintendent, Brown Company, Portland, Me.

Karl M. Mann, president, Farm Light & Power Publishing Co., 225 W. 34th St., New York City.

Peter T. Montfort, assistant research agricultural engineer, A. & M. College of Texas, College Station, Texas.

M. F. Thurmond, assistant professor of agricultural engineering, A. & M. College of Texas, College Station, Texas.

Edward G. Titus, in charge of agricultural research work, Dippe Brothers Seed Company, Quedlinburg, Germany. (Mail) 1228 Bryon Ave., Salt Lake City, Utah.

Charles E. Wise, Jr., field agricultural engineer, Portland Cement Association, Philadelphia, Pa.

Transfer of Grade

Harold A. Arnold, instructor, University of Tennessee, Knoxville, Tenn. (Student to Junior)

K. I. Church, field agricultural engineer, Portland Cement Association, Kansas City, Mo. (Junior to Associate Member)

Carl D. Gross, supervisor of rural sanitation, Illinois Department of Public Health, Springfield, Ill. (Junior to Associate Member.)

Olin E. Hughes, student trainee, J. I. Case Threshing Machine Co., Racine, Wis. (Student to Junior)

Jess H. Neal, instructor in agricultural engineering, University of Minnesota, St. Paul, Minn. (Junior to Associate Member.)

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the November issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Arthur J. Bell, extension engineer, U. S. Department of Agriculture, East Lansing, Mich.

James H. Craig, special plow salesman, International Harvester Co., Chattanooga, Tenn.

John E. Hoffman, designer and draftsman, Deere and Mansur Works, Moline, Ill.

Herman E. Kiefer, vice-president, Mason Alfalfa Process Co., 1520 Locust St., Philadelphia, Pa.

Clarence V. Sorenson, vice-president, Attica Electric Co., Attica, Ind.

Placido Vargas, manager, J. Vargas e Hjjos, Ave. Matamoros 1213, Torreon, Coahuila, Mexico.

Transfer of Grade

Lynwood W. Gray, agricultural engineer, Georgia Power Co., Atlanta, Ga. (Associate Member to Member.)

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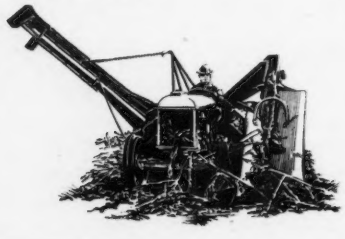
An Essential Factor in Modern Farming

On every farm, large or small, there is need for a motor power unit, to operate light draft machines that cannot be economically handled by tractors now available. The CULTOR fills this need exactly. It handles any implement ordinarily drawn by a two or three horse team, is cheaper to own and operate, and does the work better, faster and at lower cost.



The CULTOR will help any farmer put his production on a business basis. Designed originally for cultivating all kinds of rowed crops, the CULTOR just as successfully pulls the plow, drill, planter, mower, corn harvester or any other similar machine. Field work is done right at the right time, which results in larger yields of better crops.

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Makers of the CONTINENTAL Corn Pickers for the Fordson

Engineering Library

DEC 14 1927

AGRICULTURAL ENGINEERING

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Who But An Engineer?

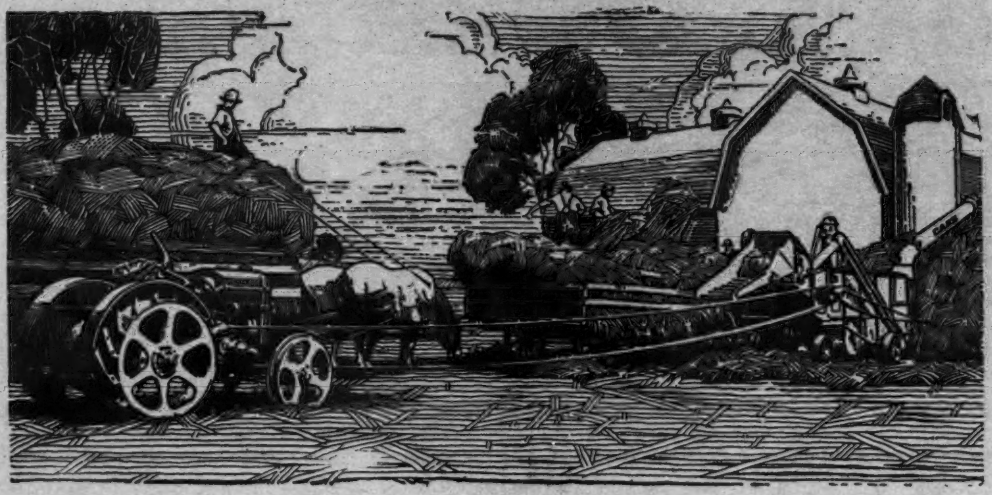
AGRICULTURE since 1920 has been operating under entirely different conditions from those under which it had been operating previous to that time. In the old days any man who went on a farm and stayed there could depend on the increase in land values making him fairly well off. Now he has to get it out of the soil, and the farm is no longer a refuge for the incompetent unless he wants to live like a pioneer.

We have come to a period when all the economies which made other industries profitable must be applied, and in agriculture who but an engineer can figure what these economies are?

I believe farmers generally are getting, and are likely to get, more help from the engineers than from any other single source.

PHILLIP S. ROSE

DECEMBER-1927



Away Back When—

IT IS NOW nearly 86 years since this Company began its work of building, developing and improving power farming machinery.

At that time, the greatest need of farmers was relief from the time-wasting labor of hand threshing, which restricted the planting of grain to a few pititful acres per man.

The founders of this Company saw the way out. They determined to produce machines which would enable farmers to plant and save enough grain to make grain growing profitable. Because of their faith, vision and persistence it is now commonplace for individual farmers to raise and save hundreds of acres of golden grain each year.

Progressive farmers were quick to appreciate this contribution to the progress of Agriculture. By their purchases of Case machines they have made this Company the largest manufacturer of threshing machines in the world, and one of the leading producers of power farming machinery.

To show our appreciation of this co-operation, for which we are profoundly grateful, we shall endeavor to deserve, in all the years to come, the whole hearted support we have received since 1842.

Established 1842

The sign of mechanical excellence the world over

J. I. Case Threshing Machine Co.

Incorporated Established 1842

Dept. M-58 Racine, Wisconsin

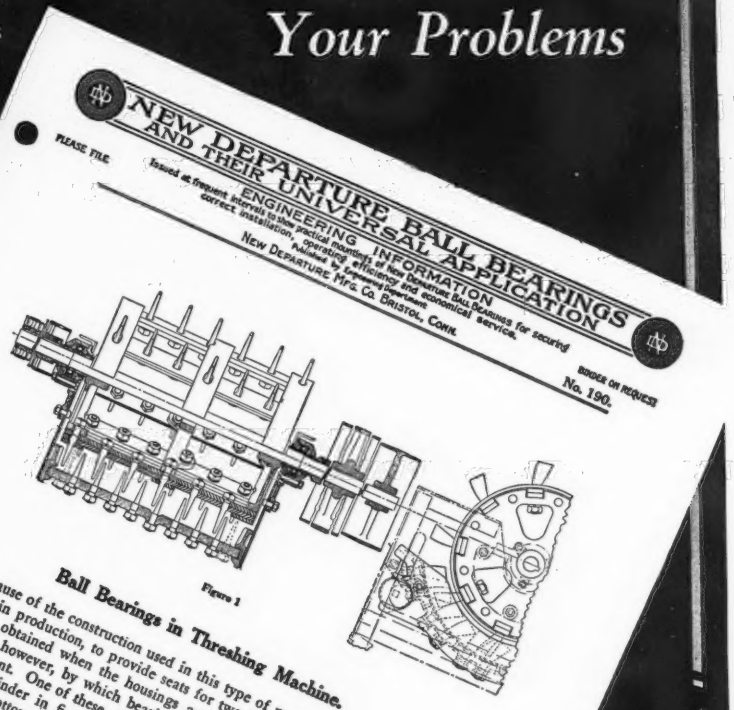
CASE

TRADE MARKS REG. U. S. PAT. OFF. AND IN FOREIGN COUNTRIES

Another New Departure Product—

Help in Thinking Out Your Problems

NEW Departure engineers build success for their clients by studying matters usually considered outside the responsibility of parts suppliers. Just one of these important services is the New Departure engineering data sheet. Ask us what it is—how it can help you — and how you can get those that apply to your problem. No cost. No obligation.


NEW DEPARTURE BALL BEARINGS AND THEIR UNIVERSAL APPLICATION

ENGINEERING INFORMATION

PLEASE FILE

Issued at frequent intervals to show practical mountings of New Departure Ball Bearings for securing correct installation, operating efficiency and economical service.

NEW DEPARTURE MFG. CO. BRISTOL, CONN.

BOOKS ON REQUEST No. 190.

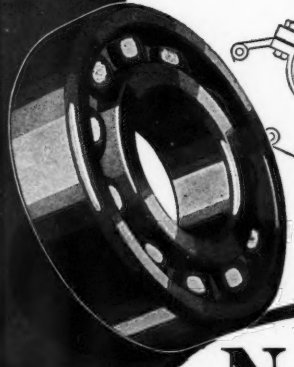
Figure 1

Ball Bearings in Threshing Machine.

Because of the construction used in this type of machinery, it is frequently impossible, in production, to provide seats for two bearing housings so that exact alignment is obtained when the housings are bolted to the frame. There are various ways, however, by which bearings may be mounted to compensate for this misalignment. One of these, shown in figure 1. Here the bearing housings are made with the thresher cylinder in figure 2, is the mounting used for slightly convex bottoms. A thin lead pad is placed between the housing and the frame member and when the housing is bolted down tight the lead conforms under pressure to the convex surface. When the housings are adjusted for alignment at the final assembly the bolts are loosened temporarily and the housings moved as required. A simple and, for this purpose, very satisfactory mounting results.

Figure 2

Ball bearings having races ground to a very large radius to permit of operation under greater misalignment than is possible with the st... Single Row bearings ... race curvatures do... radial or th...



The New Departure Mfg. Company
Bristol, Connecticut
San Francisco
Detroit
Chicago

788

New Departure Quality Ball Bearings

Many farm women, too, now have electric laundries.

Rural electrification

—a fact on more than 260,000 farms

AS the result of cooperative investigation carried on in twenty states, electric light and power companies are now building rural lines as fast as circumstances will permit.

On 260,000 farms rural electric service is in successful operation today.

The same force which has done so much for in-

NATIONAL ELECTRIC

29 West 39th Street

dustry will soon be available to an increasing number of farms. The resources and experience of more than forty years of successful city service are back of this movement to bring the farmer the greatest practical help he has ever had.

With the desire to make full use of all the benefits of electric service, and with the development of new equipment, rural electrification will open a new era on the farm.

Rural lines cannot be built everywhere at once, but the light and power companies are ready to extend service to groups of farmers, which together, can use sufficient power to justify the building and maintaining of rural lines.

Rural electrification can come quickly—where farmers and the light and power companies work together for the same good end. Ask your power company for information and cooperation.

~ ~ ~

The Committee on Relation of Electricity to Agriculture is composed of economists and engineers representing the U.S. Departments of Agriculture, Commerce and the Interior, American Farm Bureau Federation, National Grange, American Society of Agricultural Engineers, Individual Plant Manufacturers, General Federation of Women's Clubs, American Home Economics Association, National Association of Farm Equipment Manufacturers, and the National Electric Light Association.

LIGHT ASSOCIATION

New York, N. Y.

A size for *every use* – Endless uses for *every size!*

FIELD work, belt work, road work... in Winter, Spring, Summer or Fall... the versatile "Caterpillar" conquers any job...in any soil or weather!

There's a "Caterpillar" track-type tractor of the right size for every farm...and a hundred profitable uses for every size. The "Caterpillar" makes work lighter and crops heavier...*cuts costs and pyramids profits!*

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Distributing Warehouse: Albany, N. Y.
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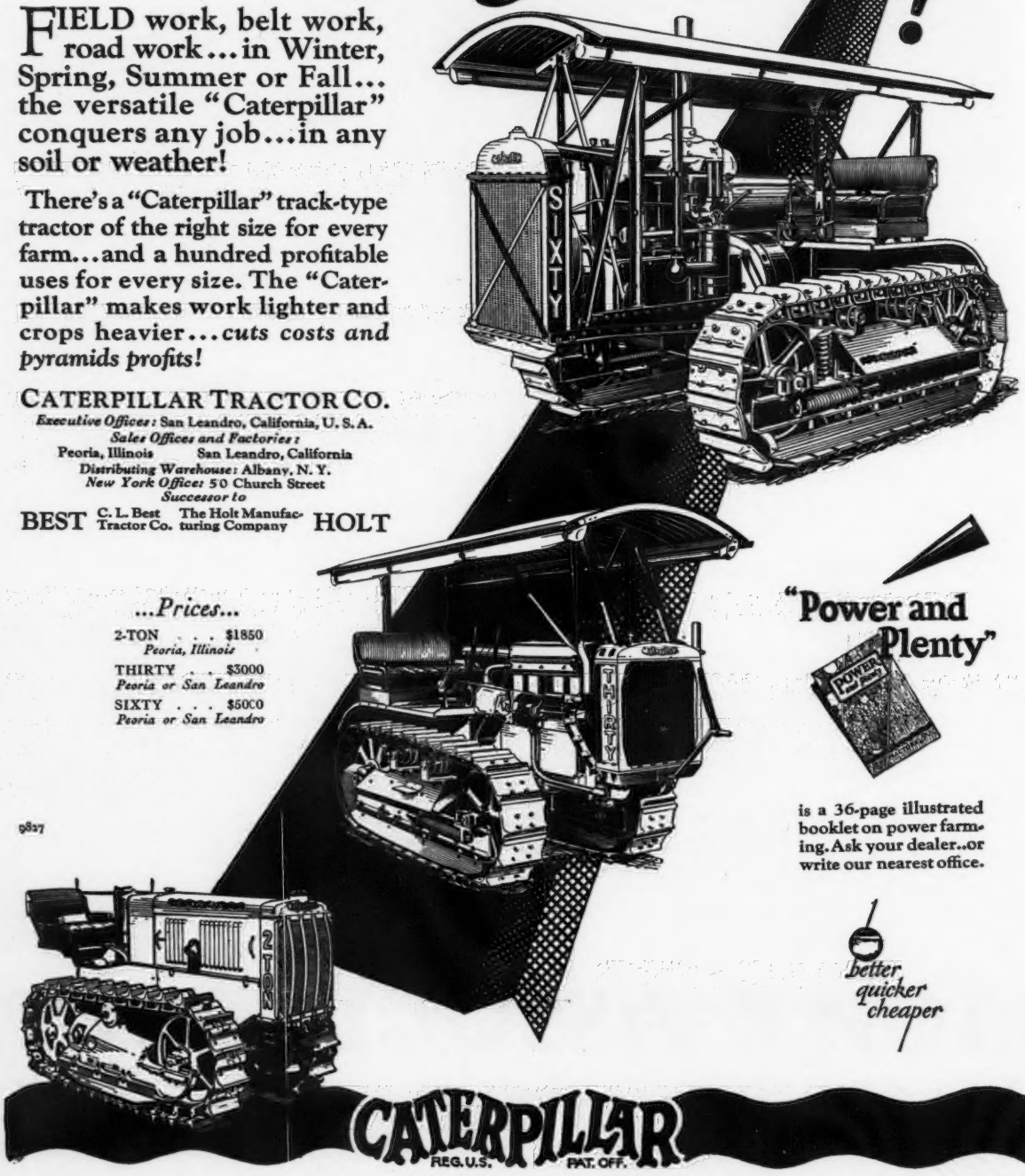
Successor to
BEST C. L. Best Tractor Co. The Holt Manufacturing Company HOLT



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is a 36-page illustrated booklet on power farming. Ask your dealer..or write our nearest office.

better quicker cheaper

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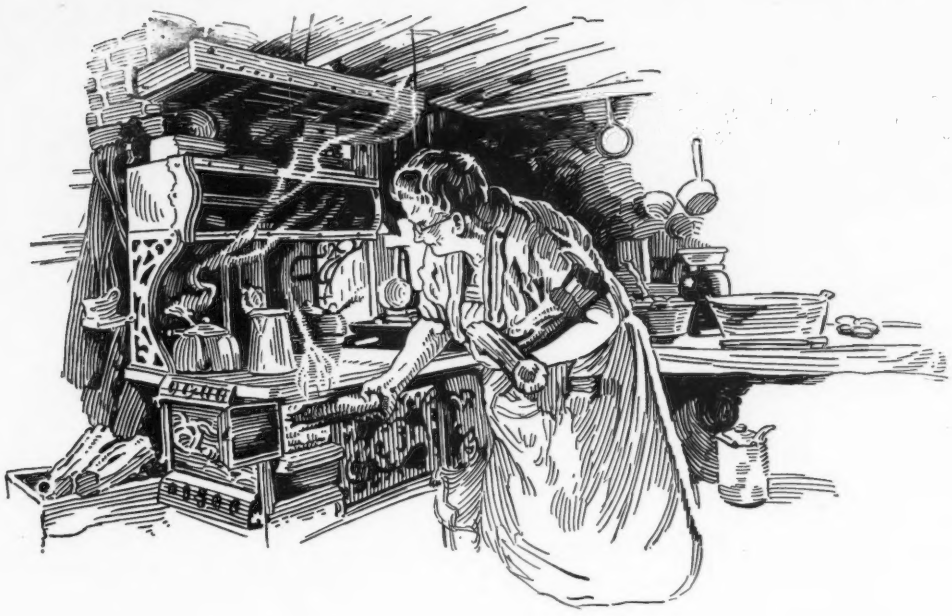


Three "Squares" a Day

THREE times a day—sometimes four—someone has to tussle with that old kitchen stove.

But how different when electricity does the cooking! No more carrying wood and coal; no more building fires; no more ashes; just the turn of a switch—and cooking is quicker, easier, and better.

Electricity also pumps water, does the week's wash, and keeps food fresh. For the men it runs the hoist, grinder, and separator, and through MAZDA lamps floods house and barn with light. By the use of an electric milker a herd of cows can be milked in half the time.

On the electrified farm—with the old stove sold to the junk dealer—the whole family enjoys three square meals a day.

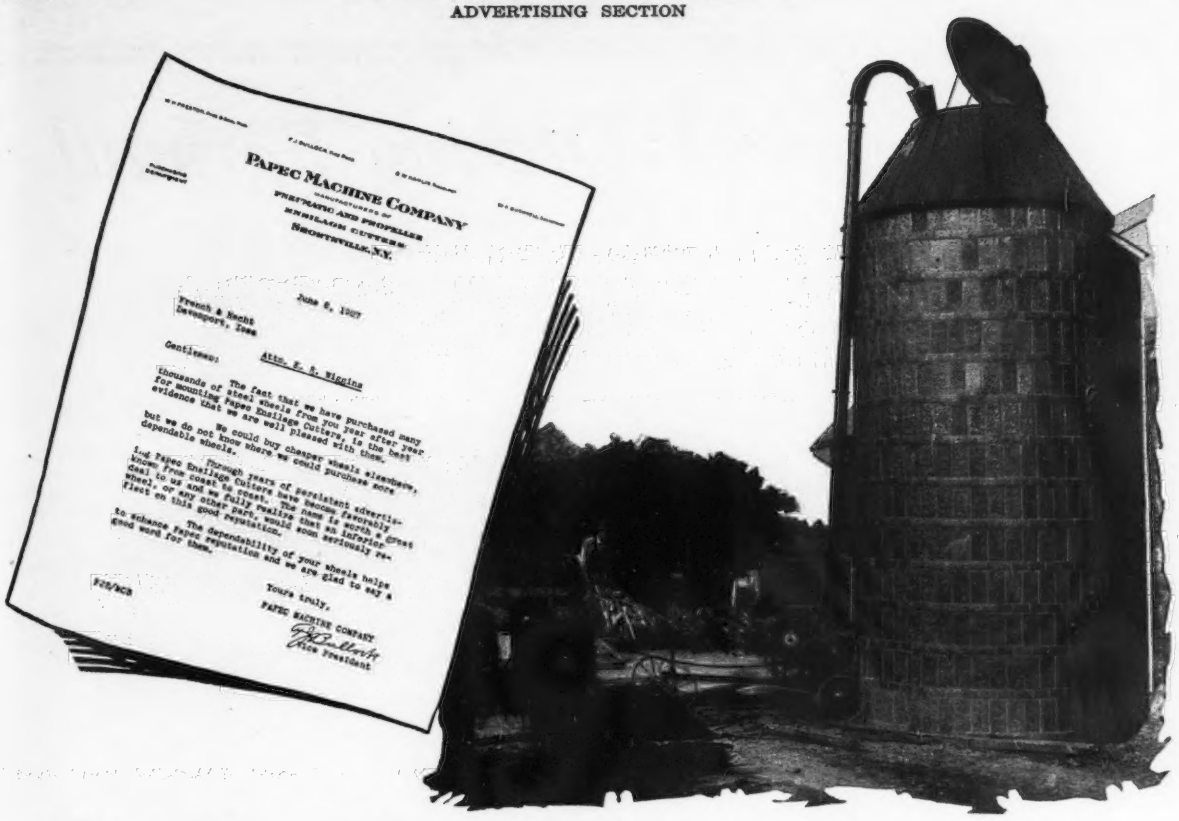
If you are on an electric line or hope to be soon, ask your electric power company for a copy of the G-E Farm Book which explains many uses for electricity on the farm.

G-E Wiring Systems, MAZDA lamps, and household equipment are making the farm home as convenient as the model house or apartment in the great city. The G-E monogram on electric motors which saw wood, hoist hay, and run cutters, grinders, clippers, and other farm machinery, is a guarantee of the quality and the enduring service General Electric builds into all of its products. Look for it when you buy electric equipment.

GENERAL ELECTRIC

One of a series of advertisements published in the leading farm papers in the interests of rural electrification.

Over 10,000 Concrete
Stave Silos Built This Year
The fact that more concrete stave silos have been built this year than all other types combined is striking evidence that the farmer is demanding a silo which is permanent. Concrete stave silos are permanent and truly economical for these reasons: the first cost is moderate; they are fire- and wind-proof, and are unsurpassed in the ability to keep ensilage fresh and sweet.
Information regarding this superior silo may be obtained from our publication, "Concrete Stave Silos," which will be mailed you upon request.
PORTLAND CEMENT Association
CHICAGO
Concrete for Permanence


PAPEC MACHINE COMPANY
June 6, 1927
French & Hecht
Davenport, Iowa
Gentlemen:
Attn. F. S. Wiggins
The fact that we have purchased many
thousands of steel wheels from you year after year
for mounting Papec Ensilage Cutters, is the best
evidence that we are well pleased with them.
We could buy cheaper wheels elsewhere,
but we do not know where we could purchase more
dependable wheels.
Through years of persistent advertis-
ing Papec Ensilage Cutters have become favorably
known from coast to coast. The Hecht name is worth a great
deal to us and we fully realize that an inferior wheel, or any other part, would soon seriously re-
flect on this good reputation.
The dependability of your wheels helps
to enhance Papec reputation and we are glad to say a
good word for them.
Yours truly,
PAPEC MACHINE COMPANY
Vice President

Including The Wheels

The Papec ensilage cutter has met with outstanding success because it is admirably designed and constructed. This silo filler is equipped with French & Hecht Steel Wheels because no other wheels would serve the purpose quite as well.

Leading manufacturers of farm machines use French & Hecht Wheels because they are mechanically correct, light in weight and so extremely strong and rigid that they outlast the machines themselves.

There can be no other wheels like them because the features that make them better wheels are exclusively French & Hecht.

French & Hecht is the largest organization in America specializing in the design and manufacture of steel wheels for Farm Implements, Tractors, Trailers, Road Machinery and other equipment. Specialized Engineering Service is offered manufacturers and users of wheels. Write.

FRENCH & HECHT

Wheel Builders Since 1888

DAVENPORT, IOWA SPRINGFIELD, OHIO

FRENCH & HECHT

STEEL WHEELS

McCormick-Deering Farmall

Though this letter is plumb-full of endorsement for the FARMALL, the most notable statement is this simple line—

"We have not yet used the cultivator."

Mr. Hastings' enthusiasm is based entirely on the *general-purpose drawbar and belt performance* of the FARMALL. In the corn and cotton fields the FARMALL is famous as the one tractor that handles row-crop cultivation like a charm. And here is first-rate evidence that it leads in general farm power work also. Keep in mind that this owner has operated several tractors of other makes. He qualifies as a practical authority in power farming and his verdict is "I believe the FARMALL is as near an all-purpose tractor as can be built."

NOTE: This advertisement is appearing for the Harvester Company in the farm equipment trade publications.

An Open Letter from—

H. G. HASTINGS COMPANY
BULBS · SEEDS · PLANTS
Atlanta, Georgia

Gentlemen:

Following a demonstration of your machine which was placed at our disposal for testing in the autumn of 1925, we purchased a machine the following spring and believe me, it has been on the job WITHOUT FAIL ever since—I believe it is as near an all-purpose tractor as can be built, and yet have a real usable quantity of power, that is, to accomplish heavy tasks.

We have used our Farmall in conjunction with two McCormick-Deering 15-30 tractors and are doing the work formerly done by five to seven tractors of other makes.

The Farmall is thoroughly competent to plow, harrow, culti-pack, drill grain, list corn or peas, plant, mow hay, operate grain binder and though we have not as yet used the cultivator, I know it will operate satisfactorily at that, as we used your outfit in testing your machine in 1925, and above all that we have used it on any number of belt jobs and find it the *most economical tractor we have yet used.*

Please do not thank me for this as it is too well deserved.

Respectfully,
D. M. HASTINGS

INTERNATIONAL HARVESTER COMPANY
606 So. Michigan Ave. of America [Incorporated] Chicago, Ill.

Permanent Fire and Lightning-Safety For Building is Assured by Steel

The Sequel to

100 Dead Cows

It took a fire which destroyed a barn and the hundred dairy cows stabled within it to convince a Georgia farmer that combustible farm buildings do not pay. After his expensive lesson, he erected the Sheet Steel clad dairy barn shown in the illustration. It is 114 feet long by 32 feet wide and is covered with galvanized Sheet Steel, both roof and sides. It has a stabling capacity of sixty cows.

This is but a typical example of the type of dairy barn that is rapidly gaining recognition as not only the safest but also the least expensive to erect and maintain.

In addition to providing dry, even temperatured, sanitary shelter for dairy cows, such a barn is fire safe and, when electrically grounded, lightning proof.

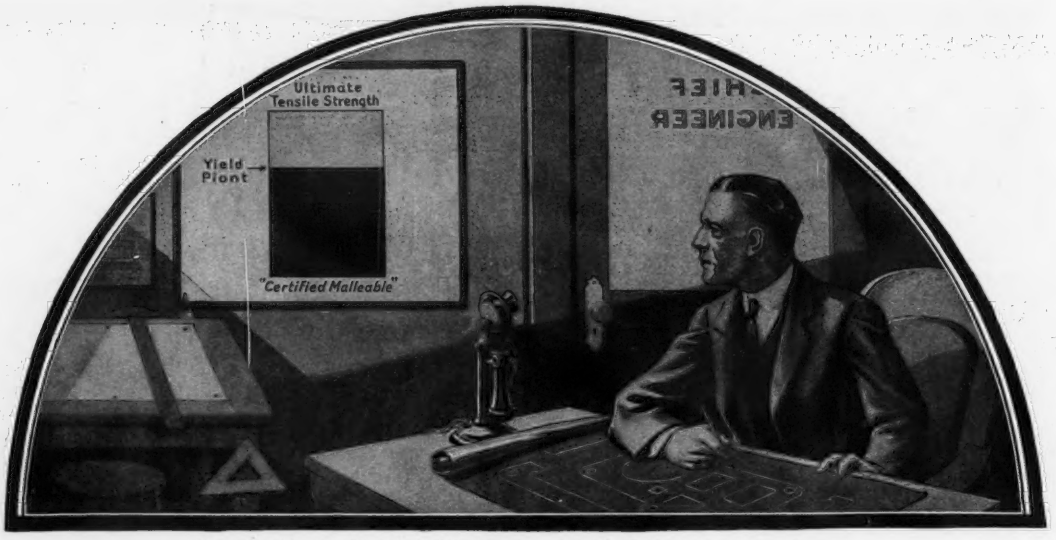
Write for the new twenty-eight page booklet, "Steel Roofing—Its Use and Application," sent free on request. Address the SHEET STEEL TRADE EXTENSION COMMITTEE, OLIVER BUILDING, PITTSBURGH, PENNA.

MASTER TEC BRAND

This trade-mark stenciled on galvanized Sheet Steel is definite insurance to the buyer that every sheet so branded is of prime quality—full weight for the gauge stamped on the sheet—never less than 28 gauge—and that the galvanizing is of the full weight and quality established by the SHEET STEEL TRADE EXTENSION COMMITTEE *specification.*

SHEET STEEL

for
STRENGTH
SAFETY
BEAUTY
ECONOMY



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Kalamazoo Malleable Iron Co.	Kalamazoo, Mich.
Laconia Car Co.	Laconia, N. H.
Lancaster Foundry Co.	Lancaster, Pa.
Lakeside Malleable Castings Co.	Racine, Wis.
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Meeker Foundry Co.	Newark, N. J.
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Northern Malleable Iron Co.	St. Paul, Minn.
Northwestern Malleable Iron Co.	Milwaukee, Wis.
Peoria Malleable Castings Co.	Peoria, Ill.
Pittsburgh Malleable Iron Co.	Pittsburgh, Pa.
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Terre Haute Malleable & Mfg. Co.	Terre Haute, Ind.
Trenton Malleable Iron Co., The	Trenton, N. J.
Union Malleable Iron Co., The	E. Moline, Ill.
Vermilion Malleable Iron Co.	Hooperston, Ill.
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High Yield Point Means Useful Strength

Certified Malleable Iron illustrates the importance of considering yield point rather than ultimate strength alone when specifying material. After all, it is useful strength of material that we must consider and pay for in designing machines or parts, and this is the strength that lies below the yield point.

Yield Point 65% of Ultimate Strength

The yield point of Certified Malleable averages about 65% of its ultimate strength. Thus Certified Malleables with a minimum ultimate strength of 50,000 pounds per square inch (A.S.T.M. Specifications) regularly exceed 30,000 pounds per square inch in yield point.

Certified Malleables are uniform in structure and quality. They regularly exceed the standard minimum specifications of 50,000 pounds tensile strength and 30,000 pounds yield point, thus assuring a uniformly high degree of useful strength as indicated by the yield point.

MALLEABLE IRON RESEARCH INSTITUTE, INC.
UNION TRUST BUILDING CLEVELAND, OHIO

POSITIVE · PHYSICAL · PROPERTIES · INCORPORATED · TRADE MARK

CERTIFIED-MALLEABLE IRON

John Deere
No. 5-A Tractor Plow

Good work and light draft first of all; then, strength to stand the strain of many years of work—those are features customers want in the plow they buy. And, because the John Deere No. 5-A Tractor Plow has those features, it is a favorite with thousands of farmers.

Most farmers already know about the genuine John Deere bottoms on the No. 5-A—bottoms that scour, pulverize the soil and cover trash with minimum draft. They will like the sturdy construction of the No. 5-A—its beams that are guaranteed not to bend or break, and the braces that are lapped extra long on the beams and heavily bolted.

They will like the easy way the new heavy-duty power lift works; they will like its strength—it is built to stand heavy, rough usage.

They will appreciate the attachments that can be furnished with the No. 5-A—

—The John Deere spring release hitch and trip rope release which save plow, tractor and trip rope from breakage when the plow hits a stump or stone.

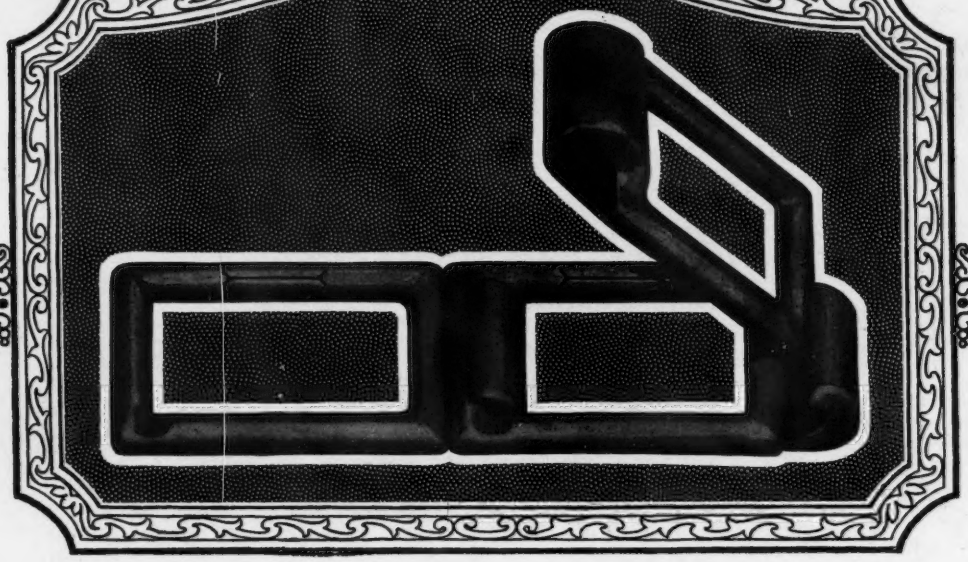
—The lever gauge wheel for use in breaking wild prairie sod.

—The subsoil attachment for use in dry regions or in regions where a plow pan exists.

—The landing lever for use in sidehill plowing.

JOHN DEERE, MOLINE, ILLINOIS

JOHN DEERE
MOLINE, ILL.



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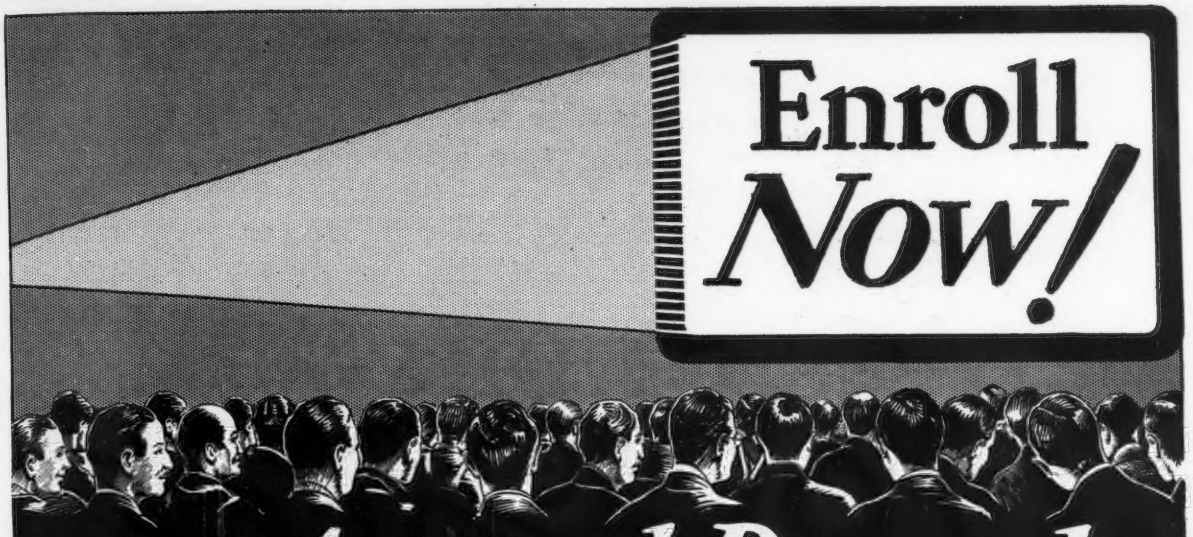
LINK-BELT COMPANY

INDIANAPOLIS, IND. 200 S. BELMONT AVE.



10th Annual Rumely POWER FARMING SCHOOLS

Intensely Practical and Valuable Instruction Presented in a New, Graphic and Vitally Interesting Way

A Rumely course of instruction for every farmer who wants to know the "ins" and "outs" of power farming machinery! Attend this course and learn with amazing clearness through the most modern and interesting method of instruction—*Visual* Instruction! You see everything pertaining to machinery operation, care, adjustment and repair—right before your eyes! You learn how experts get more work out of machinery—how they handle the same problems that puzzle you daily. You learn easily and quickly this immensely valuable knowledge.

You see thousands of feet of marvelously instructive movie film, covering a wide range of power machinery operation. *You see* power farming machinery demonstrated with clearness never before equalled. Sectional views of combines—threshers—motors—magnetos, etc.

You see "inside" mechanisms in actual operation—X-ray views that make every action simple to understand—close-ups that leave no doubts in your mind.

You see the best practice in operating tractor, thresher, combine harvester, and other power machines. In addition, the Rumely schools contain instructive lectures by experts, interesting demonstrations and exhibits, and actual machinery operation classes.

Will you miss this opportunity?

Never before has instruction been so absorbing in interest—so easy to grasp and remember! This amazing Rumely course represents the "cream" of the nine tremendously popular Rumely courses that have preceded it. Due to the new type of instruction, the time for the course has been greatly shortened—so that now every farmer who wants this valuable power farming knowledge can attend. Thousands will come! Many more schools will be held—but enrollment will be limited. Plan at once to attend the nearest school.

This valuable training absolutely FREE

You can enjoy Rumely school privileges—you can get this valuable training in power farming—you can learn, under the direction of experts, how to increase your farm profits—absolutely *free*. Write at once for details—or see your Rumely dealer. Act now—before enrollment closes.

ADVANCE-RUMELY THRESHER CO., Inc.
(Incorporated)
LaPorte, Indiana

SEND COUPON NOW!

Advance-Rumely Thresher Co., Inc.
Dept. B-K, LaPorte, Indiana
Please tell me how, without obligation, I can enroll in your Power Farming Schools.
Name .....
Address .....

ADVANCE-RUMELY

There's the Fence That Makes Money for Me

R. M. Frame, Canton, S. D., kept 21 brood sows for more than two months without feeding a bit of grain except the corn shelled and knocked off by his corn husking machine.

Six separate fields fenced hog-tight allows hogging down and gets the brood sows out on new ground for C. F. Hewitt, Morning Sun, Ia. Mr. Hewitt claims this produces 30% more pork at a minimum cost.

RED BRAND FENCE

"Galvannealed"—Copper Bearing

used for hog-tight fences around 20 acre fields will bring enough extra profits in from 1 to 3 years to pay for itself through crop rotations, hogging-down, saving green feed, roughage, etc.

Claude F. Huskin, Pekin Gap, Texas, put 500 lbs. of pork on 10 pigs by turning them into a hog-tight 1¼ acre field of dough stage corn that would go 30 bu. to the acre. He got $10.63 a hundred or $53.15, and $3.15 is all he spent for extra feed.

J. E. Hickman, Carbon, Ind., claims that a well fenced farm is worth $25 per acre more than a poorly fenced one, other things being equal.

J. H. Fuhrmann, Hennessey, Okla., lost a yearling filly and ruined the udder of a pure blooded Holstein. Then he rebuilt every line of fence.

We have thousands of other letters on file from good farmers telling how they hogged down corn; saved fallen grain, green feed and missed corn; rotated crops and made extra profits in many other ways with hog-tight fence.

RED BRAND FENCE, "Galvannealed" and copper bearing, is the good old Square Deal except better, longer lasting now than ever before. Full length, picket-like stays keep it straight; wavy strands keep it firm; can't-slip knots keep it tight; full gauge, honest weight—but protected now with copper mixed into the steel and by an extra heavy zinc "Galvannealed" coating. These two vital things keep rust out and give longer life at lower cost.

What has been your experience with or without good fence? We will pay $5.00 or more for each letter that we use. Write for details, catalog and 3 interesting booklets that tell how others have made more money with hog-tight fences.

KEYSTONE STEEL & WIRE COMPANY
9426 Industrial Street, Peoria, Illinois

Farm paper advertisements like this, appearing in all the leading state farm papers, are teaching farmers about the extra profits to be made from more and better fence. You are invited to write to the Keystone Steel & Wire Co., 9426 Industrial St., Peoria, Illinois, for farm fence evidence that Farm Extension Workers have found interesting and profitable reading. A study of this literature will make you better equipped than ever to advise intelligently on farm fencing problems.

TWIN DISC CLUTCHES

MANUFACTURERS who use thousands of clutches every year in heavy-duty machinery find that it pays them in many ways to equip their machines with Twin Disc clutches. They prolong the life of the machines, reduce the upkeep and increase the output. These superior advantages, provided by Twin Disc clutches, can be purchased at very low prices, **by any comparison.** Write the Engineering Department.

TWIN DISC CLUTCH COMPANY
RACINE WISCONSIN

NOW READY

The Prater Mill, on the operation of which the University of Wisconsin reported at the St. Paul Convention of the A.S.A.E., and which has been so enthusiastically received by Agricultural Engineers everywhere, is now in production.

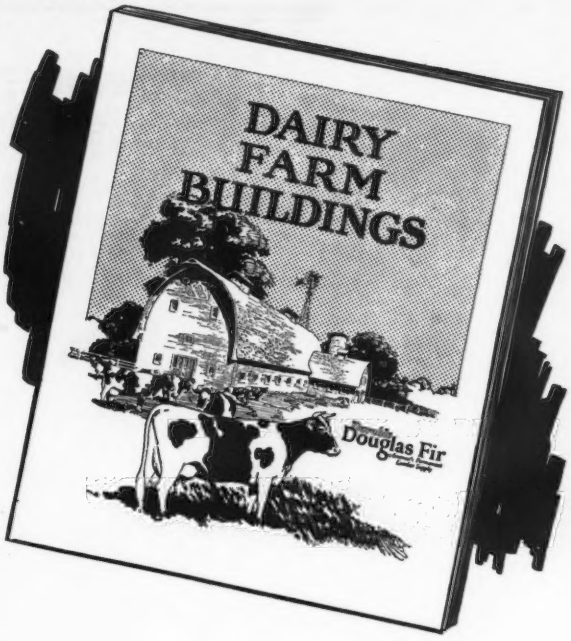
PRATER MILL Self Feeder HAMMER TYPE

Grinds 35 to 85 bu. of shelled corn per hour, and is operated by 2 H.P. Electric Motor, or 2½ H.P. Gasoline Engine. It is the mill which best meets all of these 6 requirements:

1—Satisfactory grinding
2—Not over 5 H.P. required
3—No attendant needed
4—Economical to operate
5—Reasonable in first cost
6—Simple and durable

Write for Free Catalog Folder

PRATER PULVERIZER CO.
1311 N. KOSTNER AVE
CHICAGO, ILL.



You will be interested in this new book on Dairy Farm Buildings

THIS recently issued book, written by Professor W. J. Gilmore, A.S.A.E., head of Agricultural Engineering Department, Oregon Agricultural College, gives elementary facts in simple language about the use of West Coast woods in dairy farm buildings.

The book will be delivered free to farmers, both direct and through retail lumber dealers. We will be glad to send you a copy for your comment and criticism. Address West Coast Lumber Bureau, 11B Mount Hood Building, Longview, Washington.

Durable **Douglas Fir**
America's Permanent Lumber Supply

Important West Coast Woods
Douglas Fir - West Coast Hemlock Western Red Cedar - Sitka Spruce

The First Patent on a Manure Carrier

William Louden's pioneering genius in originating and designing labor-saving barn equipment has resulted in more than 200 patents.

The Louden Manure Carrier was conceived and made practicable by his inventive mind in 1897. He holds the first U. S. Government patent ever issued on a manure carrier. With a service of 30 years behind it and improvements right down to date, in keeping with Louden leadership, the Manure Carrier is today relieving farmers and dairymen all over America of one of the worst forms of old time barn drudgery.

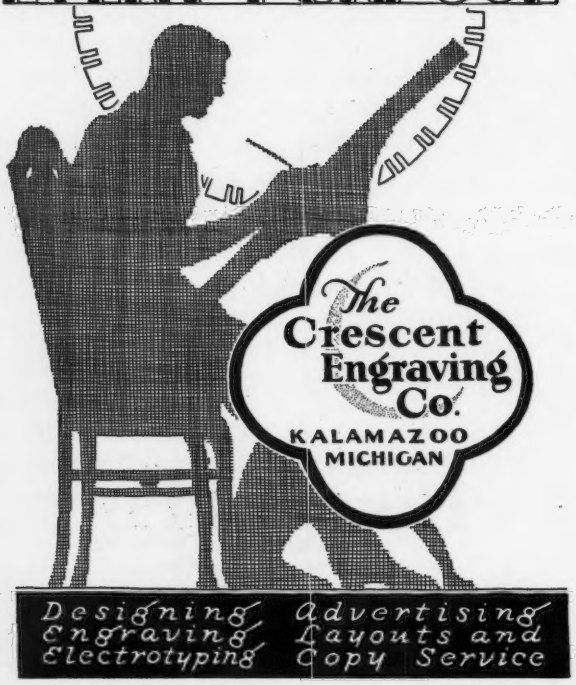
It makes an easy, speedy and convenient job of handling the loads. It is one of the foremost factors of barn sanitation as we know it today. It adds incalculably to the profits of farming.

1867
LOUDEN HISTORY
William Louden
Inventor of manure carrier which with easy hoist and big heavily built tub takes drudgery out of barn cleaning. Takes five wheelbarrow loads at a trip. Known for its exceptional quality and design.
1927

THE LOUDEN MACHINERY COMPANY
6911 Court Street (*Established 1867*) Fairfield, Iowa
Branches: Albany, N. Y. St. Paul, Minn. Los Angeles, Cal.

LOUDEN
LABOR-SAVING BARN EQUIPMENT

DRAWINGS FOR EVERY PURPOSE



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Directory of Professional Agricultural Engineers

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Drainage, Land Reclamation, River and Flood Control, Tiling, Topographic Surveys, Bridges and Reinforced Concrete Structures
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STANLEY F. MORSE
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Land Examinations, Reports, Development Plans and Estimates. Farm Inspections, Supervision, Management Drainage, Irrigation, Livestock, Fruit Growing, Forestry. Tropical Agriculture. Spanish Spoken
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Mem. A.S.A.E.

KURT GRUNWALD
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Investigations and reports covering crop adaptability in arid and humid regions, potential sugar beet production, irrigation and drainage problems, appraisals on land, supervision of farms and ranches, and selection of livestock breeds.
Medford, Long Island, New York
Mem. A.S.A.E.

WENDELL P. MILLER
Consulting Agricultural Engineer and Architect
Drainage, Development and Management of Farms, Country Estates and Golf Courses
85 East Gay Street, Columbus, Ohio
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W. K. WINTERHALTER
Consulting Agriculturist
Agricultural Investigations, Reclamation and Development of Farm Lands, Soil Improvement, Irrigation and Drainage, Farm Management. Expert Advice on Location of Beet Sugar Factories, Development of Sugar Beet Districts, and Culture of Sugar Beets and Sugar Beet Seed.
2211 Buchanan St., San Francisco, Calif.
Mem. A.S.A.E.

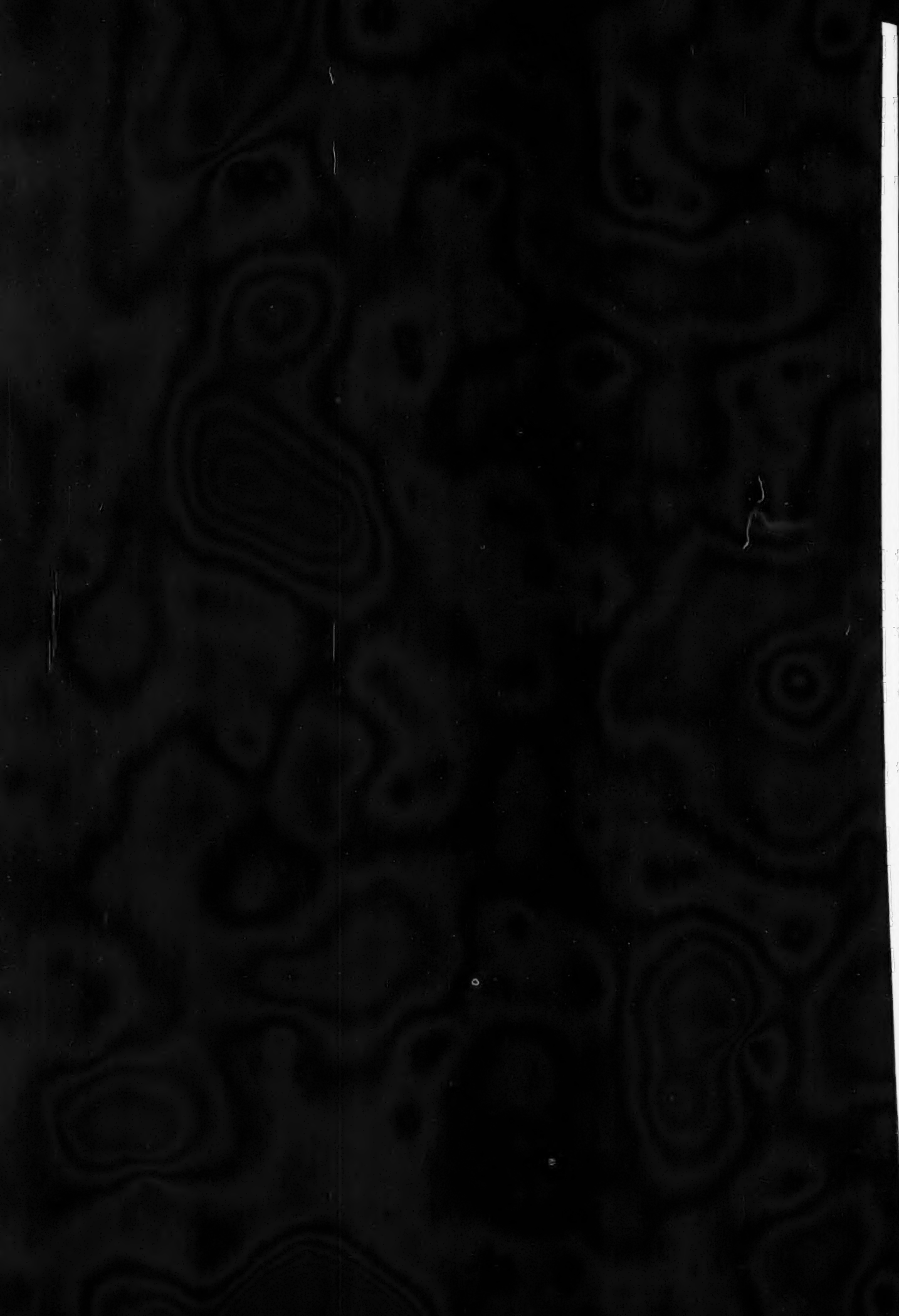
For Consulting Engineers

AGRICULTURAL engineers, who are doing consulting work or who wish to build up a consulting practice, will derive much benefit from carrying an advertisement in this Directory of Professional Agricultural Engineers. There is an increasing demand for the services of consulting engineers in the agricultural and allied industries. Those who seek to render service in this field will find that a card in this directory will help to establish their name and service in the profession.

Rates for professional cards like the above—size 1 by 3½ inches—are as follows:

To A.S.A.E. members: $2.00 per insertion for not less than 12 consecutive insertions; $3.00 per insertion for less than 12 consecutive insertions.

To non-members: $4.00 per insertion for not less than 12 consecutive insertions; $6.00 per insertion for less than 12 consecutive insertions.



For Better Service to Agriculture

AGRICULTURE, like other industries, is becoming so specialized that it is difficult to be familiar with all its many phases, yet those whose business it is to supply help and information on farm problems must have some knowledge of a wide variety of agricultural activities to make their work successful.

Dynamite is a handy tool for nearly every farmer. Of course, you know something of its more frequent uses—for land clearing, tree planting, and drainage. But there are numerous minor uses to which dynamite can be put on any farm at some time.

These occasional uses, as well as the major ones, are fully covered in **"Land Development with Hercules Dynamite."** This handbook contains all the information you need to do any kind of agricultural blasting. You should read it now as a text and keep it for reference when you get on the job. Fill out the coupon below for a free copy.

HERCULES POWDER COMPANY
(INCORPORATED)
912 Market Street, Wilmington, Delaware

- -

Hercules Powder Company,
912 Market Street
Wilmington, Delaware

Please send me a free copy of "Land Development with Hercules Dynamite."

Name .....

Occupation .....

City..... State.....

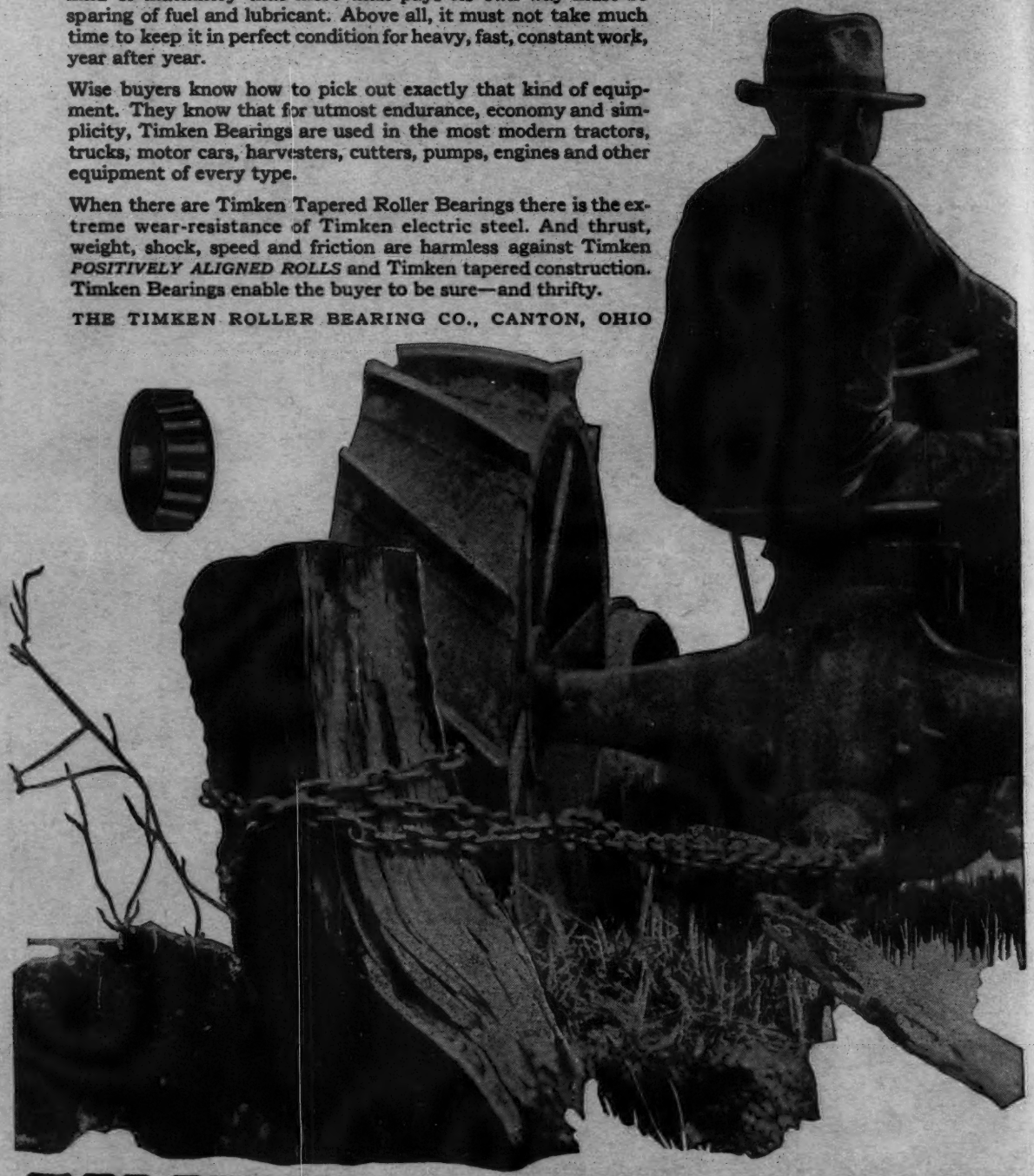
Sure—and Thrifty

From the very first field operation, until each crop is under cover or at market, machinery saves time and effort, as you know. The kind of machinery that more than pays its own way must be sparing of fuel and lubricant. Above all, it must not take much time to keep it in perfect condition for heavy, fast, constant work, year after year.

Wise buyers know how to pick out exactly that kind of equipment. They know that for utmost endurance, economy and simplicity, Timken Bearings are used in the most modern tractors, trucks, motor cars, harvesters, cutters, pumps, engines and other equipment of every type.

When there are Timken Tapered Roller Bearings there is the extreme wear-resistance of Timken electric steel. And thrust, weight, shock, speed and friction are harmless against Timken *POSITIVELY ALIGNED ROLLS* and Timken tapered construction. Timken Bearings enable the buyer to be sure—and thrifty.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO



TIMKEN *Tapered Roller* **BEARINGS**